

KOBER'S
URONOLOGY.

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Charles H. Crane, M.D.

Assistant Surgeon General U.S. Army
Washington D.C.

Dear Sir:

I beg leave to present you by the bearer
with a copy of a little volume, which
I have taken the liberty to dedicate to
you in token of admiration, gratitude
and regard.

Hoping that the dedication, eman-
ating as it does from an humble
source, may not give you offense.

I have the honor to remain

Very Respectfully
Your grateful servant
Geo. M. Hoben,

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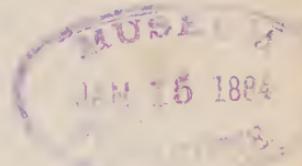
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AND ITS

PRACTICAL APPLICATIONS:

A GUIDE TO THE EXAMINATION OF URINE AND ITS DIAGNOSTIC VALUE, WITH EXTRACTS FROM THE WORKS OF THE MOST MODERN INVESTIGATORS.

BY

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1875.



NLM

TO

CHARLES H. CRANE, M. D.,
ASSISTANT SURGEON-GENERAL UNITED STATES ARMY,

IN TOKEN OF

ADMIRATION, GRATITUDE AND REGARD,
THIS LITTLE VOLUME IS RESPECTFULLY INSCRIBED BY
THE AUTHOR.

P R E F A C E.

In offering this little volume to the Medical Profession, the author begs leave to state, that it was written two years ago, at a time when there existed, in reality, a necessity for a concise guide to the examination of urine. A year ago it made its appearance *seriatim* in the "Richmond and Louisville Medical Journal," and through the generosity of its editor, Dr. E. S. Gaillard, I am enabled to present the subject to my medical friends in a more compact form.

CONTENTS.

	PAGE.
Normal Urine	3-19
Composition	3
Physical Character of Urine	9
Reäction	10
Accidental Ingredients	13
Changes in Urine during Decomposition	14
Abnormal Urine	19
Color	22
Odor	28
Specific Gravity	29
Reäction	32
Urea Increase and Deficiency	38
Creatine and Creatinine	47
Uric Acid and Urates	47
Phosphates	54
Chlorides	58
Sulphates	62
Oxalate of Lime	63
Bile	67
Sugar	70
Inosite	75
Extractive Matters	75
Albumen	76
Blood.	80
Fibrin	79
Fat	83
Hippuric Acid	85
Leucine	85
Tyrocine	85
Cystine	86
Xanthine	86
Hypoxanthine	87
Allantoine	87
Mucus and Epithelium	87
Pus	89
Cancer and Tuberclie Masses	90
Cylinders and Renal Casts	91
Kidney Structure	93
Spermatozoa	93
Entozoa	93
Systematic Analysis of Urine	93
Prostatic Calculi	99
Urinary Calculi	99
Explanation to Illustrations	101

Uro-microscopy, after Dr O. Funke,

Fig. 1.



Fig. 2.



Fig. 3.



Fig. 4.



Fig. 5.



Fig. 6.



Richmond and Louisville - Medical Journal.

Uro-microscopy, after Dr O. Funke,

Fig. 1.



Fig. 2.



Fig. 3.



Fig. 4.



Fig. 5.



Fig. 6.



Uro-microscopy, after Dr. O. Funke, Vogel & Lamb.

Fig. 1.



Fig. 2.

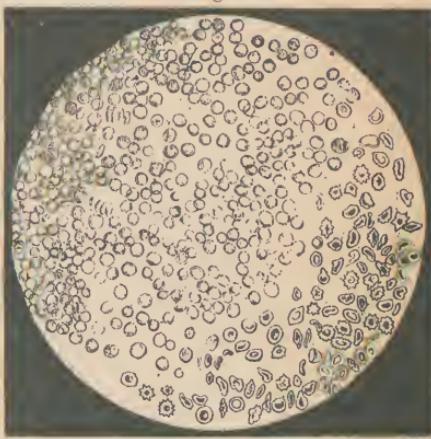


Fig. 3.

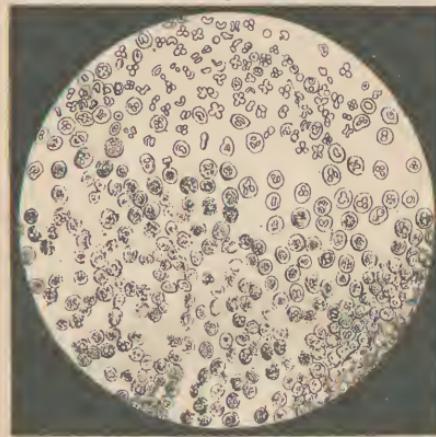


Fig. 4.



Fig. 5.

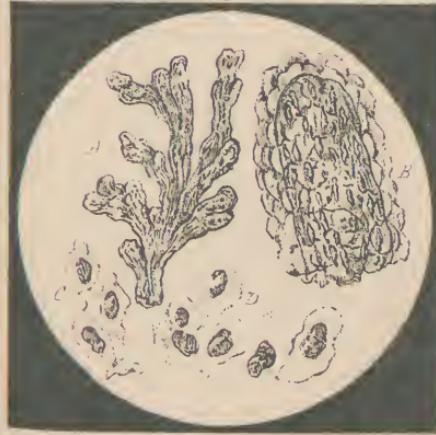
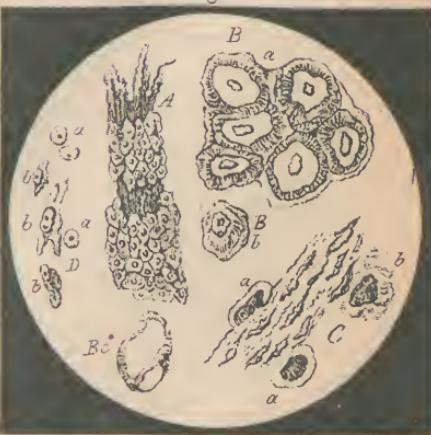


Fig. 6.



URONOLOGY AND ITS PRACTICAL APPLICATIONS:

A GUIDE TO THE EXAMINATION OF URINE AND ITS DIAG-
NOSTIC VALUE, WITH EXTRACTS FROM THE WORKS
OF THE MOST MODERN INVESTIGATORS.

With the progress of medical science, the study of urine has been well presented, and I am glad to say, with the most satisfactory results. It seems strange that medical men have not heretofore attached more importance to urine in diagnosis; but when we remember that there were and are a class of physicians who pretend to diagnosticate and treat their cases by an ocular inspection only of the fluid, we need not wonder that the earnest and educated physician, as well as the enlightened public, became disgusted with the subject of "urinary diagno-

* So much time and labor have been expended upon this very valuable series of papers, that the editor of this Journal has had prepared, as an accompaniment, accurate plates of all normal and abnormal urinary deposits. These beautiful and complete plates are copied from Neubauer's and Vogel's masterly work on Urinary Analysis, and Otto Funke's valuable Physiological Atlas. The whole will form the most valuable guide to be found in the study of urines and the varied urinary deposits manifested by the microscope.—E. S. G.

sis." It would be simply absurd to attempt to diagnosticate every case by the character of the urine, or to resort to an examination in every simple and well-pronounced disease; yet the value of urine in diagnosis is certainly great, and will aid and supply us with light in obscure cases of the many diseases of mankind.

It is difficult to say how much information can be obtained from an examination of urine. We can form some idea, however, when we remember that the kidney and its functions are important to the human economy, and that disease of this or any other organ or part of the body would materially influence the quantity or quality of the excreted fluid, and thus indicate not only the condition of the secreting organ, but also the state of the blood, as well as other changes which may be going on in the body. We not only obtain valuable information from an examination of urine in disease, but can judge the condition of the system in general. Thus the surgeon often receives encouragement to operate, if the urine is in a normal condition, or a warning, by some abnormal ingredient in the fluid, not to perform the operation.

During my studies of general and special pathology, I was impressed with the importance of a knowledge of normal and abnormal urine, and became convinced that the study of the changes of this excretion during disease would prove an invaluable aid in diagnosis, prognosis, and treatment.

But I also felt that the student and practitioner were in want of a concise guide to the examination of urine and the study of its pathological indications. I therefore determined to gather as much information on the subject as time would permit.

It has been my aim in these papers to arrange and adapt from various sources the points of most importance to the physician, not the professed chemist, and I can but hope that this will meet with the approval of the Profession.

Much of the information contained in this "Guide" is obtained from Dalton's "Physiology," Neubauer's and Vogel's "Analysis of Urine," Thudichum's "Manual of Chemical Physiology," Bird and Beale on "Urinary Deposits," Flint's

and Aitken's "Practice of Medicine," and last, but not least, DaCosta's "Medical Diagnosis."

I have carefully weighed the statements of these eminent writers, and have taken the liberty to differ from them whenever I had good reason to do so.

Normal Urine.—Before we can appreciate the changes which take place in urine during disease and their pathological relations, it is necessary to be acquainted with physiological urine and its chemical composition. We know that the functions of the kidney are to eliminate from the system water and nitrogen, and to take from the blood many of its salts and certain effete materials, whose presence would otherwise prove injurious to the economy. This beautiful and interesting process is constantly going on in the kidneys, the excreted fluid is brought from there to the bladder, from which it is finally discharged.

Urine is chemically composed, according to the analyses of Berzelius, Lehman, Becquerel, and others, of the following constituents:

Water,	-	-	-	-	-	938.00
Urea,	-	-	-	-	-	30.00
Creatine,	-	-	-	-	-	1.25
Creatinine,	-	-	-	-	-	1.50
Urate of soda,						
Urate of potassa,	}	-	-	-	-	1.80
Urate of ammonia,		-	-	-	-	.30
Coloring matter and mucus,	-	-	-	-	-	
Biphosphate of soda,						
Phosphate of soda,	}	-	-	-	-	
Phosphate of potassa,		-	-	-	-	12.45
Phosphate of magnesia,						
Phosphate of lime,						
Chlorides of sodium and potassium,	-	-	-	-	-	7.80
Sulphate of soda and potassa,	-	-	-	-	-	6.90
						1000.00

Some physiologists regard traces of lactic acid and oxalate of lime as normal constituents. I need hardly say that the proportionate quantity of the above ingredients is not absolute, but only approximate, and that they vary from time to time, within certain physiological limits, like the ingredients of all other animal fluids.

Water.—We find that the quantity of water is sufficiently

large to hold all the solid constituents in solution, being in excess of nature's want, it is eliminated, like any other useless material in the human economy. The quantity of water in urine varies considerably in health; of its variations, I shall speak more fully hereafter.

Urea. — $\text{C}_2\text{H}_4\text{N}_2\text{O}$ [old.] $\text{CH}_4\text{N}_2\text{O}$ [new]. Is a neutral, crystallizable, nitrogenous substance, readily soluble and easily decomposed by external influences. The blood is the true source from which it is supplied to the urine; according to Picard it exists in the blood in the proportion of 0.016 per thousand. Owing to the constant elimination by the kidneys, an accumulation in the circulating fluid is impossible, but this condition takes place when the kidneys are extirpated, the renal arteries ligated, or the functions of the organ, by inflammation (or otherwise) interfered with. Under such circumstances it has been found in the proportion of 1.4 per thousand. Urea is doubtless the product of the change of nitrogenized substances, and will hence vary considerably with the food partaken of, as well as with the activity of transformation of structures in the system. The proportion found in urine is 30 parts per 1000. The quantity excreted by an adult in twenty-four hours is stated by different authors as 408, 487, 500, 542, and 670 grains. Mental and bodily exercise, age, weight, and sex, and many other influences, will produce variation. The following table of Lehman illustrates variation produced by the different kinds of food:

Kind of Food.	Daily quantity of Urea.
Animal,	793 grains.
Mixed,	437 "
Vegetable,	337 "
Non-nitrogenous,	231 "

The diurnal variation is also to be remembered by the physician; a smaller quantity is produced during the sleeping hours than during the day; this is probably due to the greater activity, during waking hours, of the muscular, mental, and digestive functions. This difference is observed in patients confined to bed. More urea is produced in the latter half than in the

earlier half of the day ; and the greatest quantity is discharged during the four hours from $6\frac{1}{2}$ to $10\frac{1}{2}$ A. M.

To obtain urea from the urine, evaporate the latter while fresh in a water-bath until it has a syrupy consistency. It is then mixed with an equal volume of nitric acid, which forms nitrate of urea. This salt being less soluble than pure urea, rapidly crystallizes, after which it is separated by filtration from the other ingredients. It is then dissolved in water and decomposed by carbonate of lead, forming nitrate of lead, which remains in solution, and carbonic acid which escapes. The solution is then evaporated, the urea dissolved out by alcohol, and finally crystallized in a pure state. Urea has no tendency to spontaneous decomposition, and may be kept, when perfectly pure, in a dry state or dissolved in water, for an indefinite length of time. If the watery solution be boiled, however, the urea is converted, during the process of ebullition, into *carbonate of ammonia*. One equivalent of urea unites with two equivalents of water, and becomes transformed into two equivalents of carbonate of ammonia.

Organic impurities, acting as catalytic bodies, will induce the same change, if water be present. Animal substances in a state of commencing decomposition are particularly liable to act in this way. In order for this conversion of the urea to take place, it is necessary that the temperature of the mixture be not far from 70° to 100° F.

Creatine.— $\text{C}^4 \text{H}^9 \text{N}^3 \text{O}^2 + \text{H}^2 \text{O}$ [new formula]. This is
 $\text{C}^8 \text{H}^9 \text{N}^3 \text{O}^4 + {}^2 \text{H O}$ [old formula].

described as a neutral crystallizable substance, soluble in water, slightly so in alcohol, and not at all in ether. It is derived from the disintegration of muscular tissue ; it is found in the blood, its proportion, however, is not determined ; in the muscles it is found in the proportion of about 0.67 parts per thousand ; in the urine in proportion of about 1.25 parts per thousand.

It is converted into creatinine by being heated with strong acids, when it loses two equivalents of water. Boiling it with an alkali will either convert it into carbonic acid and ammonia,

or will decompose it, with the production of urea and an artificial nitrogenous, crystallizable substance, called *sarcosine*.

Creatinine.— $C^4 H^7 N^3 O$ [$C^8 H^7 N^3 O^2$]. Is also a crystallizable substance, the only difference between it and creatine consists in its having two equivalents less of water. It is found, like creatine, in the blood, muscles, and urine, and is probably produced by transformation of parts of creatine, since we find it in less quantity than creatine in urine. It is more soluble in water and alcohol, and slightly so in ether. It has a distinct alkaline reäction.

Urate of Soda.—This is a neutral salt, formed by the union of soda and a nitrogenous animal acid, known as *uric acid* $C^5 H^4 N^4 O^3$ [$C^{10} H^4 N^4 O^6$]. Many authors consider uric acid as though it were itself a proximate principle and a constituent of the urine; but it can not properly be regarded as such, since it never exists in a free state in normal urine, and its presence can only be determined by the addition of strong acids, which will decompose the soluble *urates* and liberate *uric acid*. Whenever uric acid is present, therefore, it has been produced by the decomposition of the urate of soda.

Urate of soda is found in the urine and blood, and is, like urea, the product of the metamorphosis of tissue, from which it is absorbed by the circulating fluid and carried to the kidney, there to be eliminated in company with other ingredients of the urine. The average daily quantity eliminated by the healthy human adult is, according to Lehman, twenty-five grains. This substance exists in the urine of the carnivorous and omnivorous animals, but not in that of the herbivora. In the latter, it is replaced by another substance, differing somewhat from it in composition and properties—viz., *hippurate of soda*. The urine of herbivora, however, while still very young, and living upon the milk of the mother, has been found to contain urates. But when the young animal is weaned, and becomes herbivorous, the urate of soda disappears, and is replaced by the hippurate. [Dalton.]

Urates of Potassa and Ammonia.—These closely resemble

urate of soda in their physiological relations ; they are found in small quantities in urine. The deposit formed by their precipitation is of a pink color, sometimes brown, or even white. They are decomposed by strong acids with the formation of crystals of uric acid. Both are soluble in hot water, but their deposit takes place as soon as the temperature is lowered.

The substances now described resemble each other, as they all contain nitrogen, are crystallizable, and soluble in water. They are the result of the wear and tear of the body, produced by the decomposition or catalytic transformation of the organic or albuminoid constituents of the body, and being taken up by the blood as effete material, are carried to the kidney, there to be removed. These excrementitious matters are themselves decomposed, after being expelled from the body, under the influence of air and moisture, so that the resolution and destruction of the organic substances are at last complete.

The coloring matter of urine consists of a substance called *urophæin* [*urohæmatin*] ; and, according to Heller, *uroxanthin* [*indican*, after Schunk]. This latter pigment is found only in small quantity. In normal urine, it is decomposable by strong acids and heat into a red pigment *urrrhodine*, and a blue pigment *uroglaucline*. The former identical with indigo-red, and the latter with indigo-blue. The pigment *urohæmatin* contains iron, and closely resembles the pigment of the blood. Dalton describes the coloring matter, *urosacine*, as yellowish-red, readily adhering to insoluble matters, and that these, when precipitated, are more or less deeply colored, according to the quantity precipitated with them. Thudichum asserts that a substance called by him "*urochrome*," is the only normal coloring pigment in the urine, and that all other named pigments are only products of decomposed *urochrome*.

Be this as it may, other writers are nevertheless correct as to the significance they attribute to these coloring pigments in disease. It is supposed that they are the product of disintegrated red blood corpuscles; certainly, a very plausible theory. In

health, the color of urine is influenced by various sorts of food and drink.

The mucus in normal urine is derived from the lining membrane of the urinary passages, and is interspersed with epithelial cells from the kidneys, ureters, and urethra. It can only be detected after the urine has been allowed to settle in a glass tube, where it may be perceived as a flocculent, cloudy mixture at the bottom.

When I come to speak of the changes in the urine during decomposition, it will be seen that the mucus plays an important part in the process of fermentation, etc. Not unfrequently spermatozoa are seen in it under the microscope.

Biphosphate of Soda is held in direct solution in the urine; it is this salt which gives the urine its acidity, as there is no free acid present in its recent condition. [See page 6.] It is most likely derived from the neutral phosphate of soda in the blood, which is decomposed by the *uric acid* at the time of its formation, thus producing a *urate of soda* and converting a part of the neutral phosphate of soda into the acid biphosphate.

The Phosphates of Lime and Magnesia, the earthy phosphates, exist in urine by indirect solution. They are nearly insoluble in water, but are kept in solution in the urine by the *acid phosphate of soda*. They are derived partly from the food, but mostly from the disintegration or oxidation of disintegrated albuminous substances, specially of the nerve structures. When the urine is alkaline, they are deposited as a whitish precipitate, giving the urine a turbid appearance; when the urine is neutral, they are still held in solution, to some extent, by the chloride of sodium, which has the property of dissolving a small quantity of the phosphate of lime.

The Phosphates of Soda and Potassa are derived from the food and the disintegration of albuminous substances, and are held in solution by the water of the urine.

The Chlorides are derived from the food and blood; the amount eliminated in health will greatly depend upon the amount ingested.

The Sulphates are found in large quantities in urine, and are held in solution like the alkaline phosphates.

Urine thus composed constitutes *healthy urine*, which is an amber-yellow colored fluid, of an acid reäction, sometimes, however, it is neutral, and occasionally slightly alkaline. The average quantity of urine passed by a healthy adult *per diem* is between thirty and forty ounces, and its mean specific gravity is 1024. Vogel gives the amount of urine passed *per diem* as fifty-seven ounces; but I am inclined to believe, since his experience was chiefly limited to the male sex of Germany, who are for the most part beer or wine drinkers, that this average amount is by no means true of the adults in this country. The quantity and specific gravity of urine vary in health considerably; the physician should therefore not be too hasty in suspecting trouble because the specific gravity is high or low; he should remember that there are certain circumstances and conditions of the system (not at all pathological) which will tend to materially influence the *quantity* and *density* of the eliminated fluid; as for instance, if a less quantity of drink is taken into the system, or if the lungs, skin, or intestines perform their function with unwonted activity, a proportionately smaller amount of water will be eliminated by the kidneys; and as the solid ingredients of the urine remain the same in quantity, and are held in solution by the water, this solution becomes necessarily more concentrated, and its specific gravity therefore high. Then again we find, that if a large quantity of fluid is taken into the system, the temperature being low and the function of the skin diminished, the quantity of urine will be proportionately large and its specific gravity low. These changes in the specific gravity are not then produced by the quantity of solid matters, which under these circumstances remain the same in the twenty-four hours.

The physician in examining urine should also bear in mind its diurnal variation, both in specific gravity and acidity, and that the quantity of each and all of its ingredients may vary to a certain extent, without any morbid condition of the sys-

tem. The urine which has collected during the night in the bladder and is voided early in the morning, is more dense, of a higher specific gravity, and more acid than that discharged in the forenoon, and the second discharge is often neutral or alkaline in reäction. During the middle of the day, it again becomes denser, of a deeper color, and increases in acidity. All these properties become still more strongly marked during the afternoon and evening, and towards night the urine is again deeply colored and strongly acid, and has a specific gravity of 1028 or 1030.

The urine as a general rule is discharged from the bladder five or six times in the twenty-four hours.

The following tables, taken from Dalton's Physiology, will serve to show the general character of the variation in reäction and gravity:

OBSERVATION I.—MARCH 20.

Urine of first discharge, acid, specific gravity 1025.
“ second discharge, alkaline, specific gravity 1015.
“ third discharge, neutral, specific gravity 1018.
“ fourth discharge, acid, specific gravity 1018.
“ fifth discharge, acid, specific gravity 1027.

OBSERVATION II.—MARCH 21.

Urine of first discharge, acid, specific gravity 1020.
“ second discharge, neutral, specific gravity 1022.
“ third discharge, neutral, specific gravity 1025.
“ fourth discharge, acid, specific gravity 1027.
“ fifth discharge, acid, specific gravity 1030.

In examining urine, therefore, the physician should never be satisfied with the result of only one examination, but repeat the same, and then seek a conclusion.

RE-ACTION OF URINE.

I observed before that normal urine reddens blue litmus paper, showing its acid reäction; often, however, it is neutral, and again slightly alkaline. If no food has been taken for hours, it becomes highly acid, whereas, after meals, or while digestion is still going on, it is but faintly so. Urine after being discharged from the bladder remains generally acid for a

day or more. The normal acid or alkaline reäction of urine seems to depend upon the state of the blood. Under ordinary circumstances, the kidneys secrete an acid urine from an alkaline blood, showing that they have the power peculiar to their cells to separate the acid salts from the blood. When, however, the blood after the entrance of newly digested food becomes strongly alkaline, the acid reäction of the urine ceases, and it becomes neutral or slightly alkaline. The alkaline reäction of urine may also be due to the presence of a fixed alkali, like the carbonate of potassa or soda, or a volatile alkali, due to the decomposition of urea into carbonate of ammonia. In the first instance, if red litmus is dipped into the urine, it turns blue and remains so after drying. In the second instance, it becomes also blue, but its original red tint returns after the paper has been dried.

Alkalinity of urine from a fixed alkali, the result of fruits, certain articles of food and medicine, is not indicative of a morbid condition of the system. I may mention here that the salts of the organic acids, as the lactates, malates, acetates and tartrates of soda, potassa, etc., when taken into the system, are replaced in the urine by the carbonates of the same bases, and of course render the fluid alkaline. Dr. Bence Jones found that two drachms of tartrate potass. dissolved in four ounces of water and taken into the circulation, rendered the urine alkaline in thirty-five seconds; after two hours, the alkaline reäction ceased. Lehman found in one instance by experimenting upon a person with congenital extroversion of the bladder, in whom the orifices of the ureters were exposed, that the urine became alkaline in the course of seven minutes after the injection of half an ounce of acetate of potassa. I shall speak of this subject under abnormal urine in a subsequent paper, and point out the extent of alkalinity and its continuance as consistent with health. The alkalinity of urine depending upon a volatile alkali is always to be viewed as pathological.

Urine in its healthy and recent condition is affected by chemical and physical reägents in the following manner: Boiling the

urine of an acid reäction produces no visible change; if it be neutral or alkaline, the mixture becomes turbid, particularly so when the earthy phosphates predominate, since these salts are less soluble at a high than at a low temperature.

The addition of mineral acids will first alter the color of the urine, which assumes a brown color by the use of sulphuric acid, and determines thereby the presence of the coloring *urhæmatin*. The *hydrochloric* and *nitric* acids decompose the *urates* and deposit *uric acid* in a crystalline form upon the sides and bottom of the glass tube; these crystals are most frequently transparent rhomboidal plates, or oval laminae with pointed extremities. The microscope shows them very clearly; frequently the crystals are tinged of a yellowish hue by the coloring matter of the urine, which unites with them when they are deposited. Not unfrequently they are arranged in radiated clusters, or small spheroidal masses, so as to present the appearance of minute calculous concretions; the variance in size and form depends upon the time occupied in their formation.

If *potassa* or *soda* be added to urine, so as to neutralize its acid reäction, it becomes immediately turbid, owing to a deposit of the *earthy phosphates*, which are insoluble in alkaline fluids.

The solution of *chloride of barium* precipitates a deposit soluble in free acids [*the phosphates*], and a deposit insoluble in acids [*the sulphates*]. Nitrate of silver precipitates a yellow deposit soluble in nitric acid and ammonia [*the alkaline phosphates*], and a white precipitate insoluble in nitric acid, but soluble in ammonia [*chloride of sodium*.]

Urine contains certain organic substances, which possess the power of interfering with the mutual reäction of starch and iodine, and even of decomposing the iodide of starch after it has once been formed. This peculiar action of urine was first noticed and described by Professor Dalton. The interference occurs in all cases in which iodine exists in the urine.

When it has been administered as a medicine, it exists in the form of an organic combination; and in order to detect its presence by means of starch, a few drops of nitric acid must

be added at the same time, so as to destroy the organic matters; after which, if iodine is really present, the blue color immediately appears.

Urine also possesses the property, which depends upon some of its organic ingredients, of interfering with Trommer's test for grape sugar. If clarified honey be mixed with fresh urine, and sulphate of copper with an excess of potassa be afterwards added, the mixture takes a dingy, grayish blue color. On boiling, the color turns yellowish or yellow-brown, but the sub-oxide of copper is not deposited. In order to remove organic matter and detect the sugar, the urine must be first treated with an excess of animal charcoal and filtered. By this means the objectionable organic substances are retained upon the filter, while the sugar passes through in solution, and may then be detected as usual by Trommer's test.

ACCIDENTAL INGREDIENTS IN URINE.

Often medicinal and poisonous substances, after having been introduced into the system, are found in the urine. This is of importance to the physiologist and chemist, and in many cases to the physician. From the presence of certain medicines in the urine, we may know whether to continue them or not. For instance, if nitre, digitalis, or strychnine be given, they should be detected in the urine; their absence would prove their accumulation in the system, and the timely discovery of such a condition will sometimes prevent a fatal result. Substances which tend to unite strongly with the animal matters, and to form with them insoluble compounds, such as the preparations of iron, lead, silver, arsenic, mercury, etc., are least liable to appear in the urine. They may occasionally be detected in this fluid when they have been given in large doses, but when administered in moderate quantity are not usually to be found there. Most other substances, however, accidentally present in the circulation, pass off readily by the kidney, either in their original form or after undergoing certain chemical modifications.

Ferrocyanide of potassium, when introduced into the circulation, appears readily in the urine. Bernard* observed that a solution of this salt, after being injected into the duct of the submaxillary gland, could be detected in the urine at the end of twenty minutes. Iodine, in all of its combinations, is found in urine after it has been given. Dalton found, after the administration of half a drachm of the syrup of iodide of iron, iodine in the urine at the end of thirty minutes, and it continued to be present for nearly twenty-four hours. Quinine, ether, chloroform, tannin, and carbolic acid have been detected in the urine after having been introduced into the system.

While it would be very interesting for the physician to examine the urine for these substances, it is to be regretted that the process of analysis is not always simple.

Poisonous substances have been detected in the urine, and may be of importance in the treatment of the individual, or in legal medicine.

The presence of albumen, oxalate of lime, sugar, blood, bile, fats, and abnormal pigments are generally considered as indicating disease. I shall speak of these hereafter, and point out the exceptional conditions in which some of these substances may appear in the urine without the existence of any morbid condition of the system.

CHANGES IN THE URINE DURING DECOMPOSITION.

The urine, like any other animal fluid after its discharge from the system, and when exposed at an ordinary temperature, is decomposed, and this decomposition is characterized by certain changes which take place in a regular order of succession. I have already intimated that mucus plays an important part in the decomposition of urine. Physiology has taught us that organic substances, when beginning to putrefy, induce in certain other substances all the phenomena of fermentation. The mucus in the urine being an organic substance, soon becomes changed, particularly when exposed to a temperature between

* Leçons de Physiologie Experimentale, 1856, p. 111.

60° and 100° F., and communicates these changes more or less rapidly to the supernatant fluid. This first change is called *acid fermentation*, and produces a free acid, usually *lactic acid*, from some of the undetermined animal matters contained in the urine. This fermentation takes place very early, within the first twelve, twenty-four, or forty-eight hours, according to the elevation of the surrounding temperature. Perfectly fresh urine, as has been stated before, contains no *free acid*. Lactic acid, nevertheless, has been so frequently found in nearly fresh urine as to lead some eminent chemists (Berzelius and Lehman) to regard it as a natural constituent of the excretion. It has been subsequently found, however, that urine, though entirely free from lactic acid when first passed, may frequently present traces of this substance after some hours' exposure to the air. The lactic acid is undoubtedly formed, in these cases, by the decomposition of some animal substance contained in the urine. Its production in this way, though not constant, is sufficiently frequent to be regarded as a normal process.

It is, in consequence of this change, or the presence of this acid [lactic acid $C^3 H^6 O^3 (C^6 H^6 O^6)$], that the urates are partially decomposed, and the deposit of crystalline uric acid takes place in the same manner, as if a little nitric or muriatic acid had been added to the urine. Urine, therefore, if abounding in the urates, frequently shows a deposit of uric acid a few hours after it has been passed, though it may have been perfectly free from deposit at the time of its emission.

During the period of *acid fermentation*, Dalton believes that *oxalic acid* $[C^3 H^4 N^2 O^4 (C^6 H^4 N^2 O^6)]$ is also sometimes produced in a similar manner with the lactic acid, and that the presence of *oxalate of lime* in urine, after a day or two of exposure to the atmosphere, is not at all a dangerous or morbid symptom; "for whenever," he goes on to say, "*oxalic acid* is formed in the urine, it must be necessarily deposited under the form of *oxalate of lime*, since this salt is entirely insoluble both in water and in urine, even when heated to the boiling point." It is difficult to comprehend how the deposit of oxalate of

lime in the urine was held previously in solution. The explanation of Dalton is, "that its oxalic acid is, in all probability, formed, as stated above, in the urine itself, and that it unites as fast as it is produced with the lime previously in solution, and thus appearing as a crystalline deposit of oxalate of lime." It is much more probable that this is the true explanation, since, in the cases to which Dalton alludes, the crystals of oxalate of lime grew, as it were, in the cloud of mucus which collects at the bottom of the vessel, while the supernatant fluid remains clear.

The crystals of oxalate of lime are of minute size, and appear under the microscope in well-defined octahedra of various sizes, and dumb-bell-like bodies (the latter are not frequent), double quadrangular pyramids, united base to base, and prismatic crystals, are all occasionally observed.

Considerable difference of opinion is evinced as to the production of oxalic acid and to what extent a deposit of oxalate of lime in urine is consistent or inconsistent with the health of the individual. There can be no doubt that oxalic acid is also found in the system, since it has been found in the blood; its true source is not known.

I take the following view: If oxalate of lime is found immediately after urine has been voided, it is either the result of fermentive action in the urinary passages, or the formation of oxalic acid in the system; the history of the case will generally guide us in our opinion.

The oxalate of lime found in urine after a day or two of its exposure to the atmosphere is (I adhere to Dalton) the result of acid fermentation. Of the pathology, etc., of oxalate of lime, I shall speak more fully in a subsequent paper.

At the end of some days the changes above described come to an end, and are succeeded by the process known as "alkaline fermentation." This is nothing more nor less than the decomposition or transformation of the urea into carbonate of ammonia. As the alteration of the mucus advances, it loses the power of producing lactic and oxalic acid, and becomes a

ferment, capable of acting by catalysis upon the urea, and exciting its decomposition as above. It has been already mentioned that urea may be converted into carbonate of ammonia by prolonged boiling, or by contact with decomposing animal substances. In this conversion, the urea unites with the elements of two equivalents of water, and consequently it is not susceptible of the transformation when in a dry state, but only when in solution or supplied with a sufficient quantity of moisture. The presence of mucus, in a state of incipient decomposition, is also necessary to act the part of a catalytic body. Consequently, if the urine, when first discharged, be passed through a succession of close filters so as to separate its mucus, it may be afterwards kept for an indefinite time without alteration. But under ordinary circumstances the mucus, as soon as its putrefaction has commenced, excites the decomposition of the urea, and carbonate of ammonia begins to be developed.

According to von Tieghen, the alkaline fermentation is not dependent upon the mucus, but a peculiar torula, which is found in every urine. [See Vogel's *Anbeitung*, p. 130.]

The first portions of the ammonia will begin to neutralize the biphosphate of soda; the acid reäction of the fluid diminishes in consequence of this change, and the production of carbonate of ammonia still going on will soon render the fluid neutral and alkaline. It will be seen that these changes are dependent upon the presence of mucus, or, if you please, *torulæ*, since, if they are present, they are intimately mixed with the mucus, and it has been found that they increase in quantity, in the same affections, in which mucus increases; an increased quantity of either the mucus or *torulæ*, therefore, in combination with a high temperature will greatly influence the rapidity of the decomposition. Urine of a neutral or slightly acid reäction, when passed, will, of course, become sooner alkaline than that of intense acidity.

The fermentive process may be going on in the bladder, thus we have alkalinity of urine, due to the decomposition of urea into carbonate of ammonia, in paralysis of the bladder, simply

from the fact that the fluid is retained for many hours, and that there is nothing to antagonize the changes; on the contrary, many circumstances will favor this process—such as a high temperature, a large amount of mucus, etc.

The first effect of the alkaline condition of the urine thus produced, is the precipitation of the earthy phosphates. These salts, as I hinted in the course of their description, are held in solution by the acid biphosphate of soda, and are totally insoluble in neutral and alkaline urine. The precipitate begins to fall as soon as the natural acidity of the urine has fairly disappeared, and settles upon the sides and bottom of the vessel, or is partly entangled with certain animal matters which rise to the surface and form a thin, opaline scum upon the urine. There are no crystals to be seen at this time, and the deposit is entirely amorphous and granular in character. The next change consists in the production of two new double salts by the action of carbonate of ammonia on the phosphate of soda and magnesia. One of these is the "triple phosphate," phosphate of magnesia, and ammonia—($2 \text{M}_g \text{O N H}^4 \text{O P O}^5 + 2 \text{H}_2\text{O}$). The other is the phosphate of soda and ammonia—($\text{N}_a \text{O N H}^4 \text{O H O P O}^5 + \text{H}_2\text{O}$). The phosphate of magnesia and ammonia is formed from the phosphate of magnesia in the urine by the replacement of one equivalent of magnesia by one of ammonia; the crystals of this salt are very elegant and characteristic. They show themselves throughout all parts of the mixture, growing gradually in the mucus at the bottom, adhering to the sides of the glass, and scattered abundantly over the film which collects upon the surface. By their refractive power, they give to this film a peculiar glistening and iridescent appearance, which is nearly always visible at the end of six or seven days. The crystals are perfectly colorless and transparent, and have the form of triangular prisms, generally with beveled extremities, or resemble feather-down. Frequently, also, their edges and angles are replaced by secondary facets. They are soluble in acids, but never in alkalies. [See plate 2, fig. 3 and 5.]

The phosphate of soda and ammonia is formed by the union of

ammonia and the phosphate of soda, which latter is one of the normal constituents of urine. Its crystals resemble very much those of the *triple phosphates*, except that their prisms are of a quadrangular form, or some figure derived from it. They are intermingled with the preceding in the putrefying urine, and are affected in the same way by chemical reagents.

The carbonate of ammonia, after converting all the other ingredients with which it is capable of entering into combination, is now given off in a free form. The urine acquires at this time a strong ammoniacal smell, and a piece of moistened test-paper held a little above its surface will have its color immediately turned by the alkaline gas escaping from the fluid. This is the source of the ammoniacal vapor which is so freely given off from stables and from dung-heaps, or wherever urine is allowed to remain and decompose. This process continues until all the urea has been consumed, and until the products of its decomposition have either united with other substances, or have finally escaped in a gaseous form.

ABNORMAL URINE AND ITS DIAGNOSTIC VALUE.

I shall now consider the character of urine which has been changed during disease in quantity or quality, together with the pathological indications of these changes.

Some physicians shrug their shoulders, and to use the language of Bedford, are disposed to smile with something less than contempt, when they hear of the importance attributed to urine in diagnosis; but no independent and progressive mind will ever heed these insinuations. The educated physician can no longer scorn the idea of "urinary diagnosis," provided the examinations are conducted scientifically and with the intention on the part of the physician to study the character of disease and alleviate the suffering of mankind. The enlightened laity, when they know his motives and see that these examinations are valuable aids in diagnosis, and that they are conducted without ostentation on the part of the physician, will appreciate his skill and regard the subject as a part of the progress

of medical science. What more need be said to induce every physician to make, now and then, an examination of the urine of his patients, than to assure him that a study of the changes which take place in this excretion, during disease, will guide him in his diagnosis, prognosis, and treatment?

In examining urine, the physician should always first look and test for what he expects to find. In obscure cases of diagnosis, he ought carefully to consider and weigh all the striking points, and from repeated examinations he will arrive at a conclusion dictated to him by the language of nature; for she speaks to him not only through the symptoms in general, but also through the character of the excreta, particularly of the urine. I may add that nature never deceives, but the observer may deceive himself. Before proceeding to discuss in detail urine in its abnormal conditions, it will not be amiss to acquaint the student with some of the principal requisites for its examination.

He should have at hand accurate test solutions, the strength of each of which is exactly known; be provided with graduated pipettes for sucking up and measuring the fluid to be examined prior to its transfer to a convenient vessel; and with graduated glass instruments, or burettes, from which exact quantities of the test solutions may be dropped. Graduated flasks, also, for the preparation of the solutions for the reagents are very useful, and beaker glasses to hold the urine. A microscope is the most essential instrument in urinary diagnosis. He must also bear in mind that in the quantitative analysis, it is customary to use the French system of measures, and to employ instruments on which cubic centimetres are marked. One thousand cubic centimetres are equal to one litre, or 61.028 English cubic inches, or to a thousand grammes of water; and one gramme is equal to 15.434 troy grains. [Da Costa.]

In examining urine, the following are the details of the facts to be determined and recorded:

I.—Record the age and weight of the patient.

II.—Collect all the urine passed in twenty-four hours, meas-

ure it in cubic centimetres, and record its absolute amount.

III.—Observe and record the following general properties—viz.: 1. Specific gravity; 2. Urohæmatine, as determined by Vogel's color table; 3. Clearness or turbidity on emission or after rest; 4. Determine the absolute weight, by multiplying the quantity passed, expressed in c. c., by the figures expressing the specific gravity; the result is the weight in grammes.

IV.—Set aside the following quantities of the urine for the volumetric determination of—

1. Urea, 40 c.c.
2. Uric acid, 300 to 500 c.c.
3. Phosphoric acid, 40 c.c. [The precipitate from the urea estimation is sufficient.]
4. Chloride of sodium, 40 c.c.
5. Sulphuric acid, 100 c.c.
6. Degree of free acidity.
7. Sugar, 20 c.c.
8. Albumen.
9. Solids, 20 grammes.

V.—Collect and examine the sediment.

VI.—Determine the amount of the excretion normal to the individual by the following empirical formula (Parke's): Multiply the following figures by the weight of the person in pounds, avoirdupois; the result is the excretion in grains in twenty-four hours of the several ingredients of the urine:

	In men be- tween 20 and 40.	In women bet. 20 and 40.	In children between		In young men & wo- men bet. 16 and 20.
			3 and 8.	8 and 16.	
Urea, - - -	3.53	2.96	6.83	5.20	4.39
Chlorine, - - -	0.875	0.817	1.44	1.097	0.926
Sulphuric acid,	0.214	0.25	0.414	0.315	0.266
Phosphoric acid,	0.336	0.336	0.65	0.495	0.418

The following corrections are required: 1. If the person be between forty and fifty, calculate according to columns 1 or 2, and then deduct 10 per cent.; for ages between fifty and sixty,

deduct 20 per cent.; for ages between sixty and seventy, deduct 30 per cent.; for ages upward of seventy, deduct 50 per cent. 2. If the person has been starving for two or three days (as in some fevers), deduct one-third from the calculation made according to the table; if the diet be meagre, deduct one-eighth or one-sixth; if pretty plentiful, yet still below that of health, deduct one-tenth. 3. If there be a total inactivity, deduct one-tenth; if there be merely quietude, deduct one-twentieth. [Aitken's Practice, vol. ii., p. 899.]

COLOR OF URINE.

I shall first speak of the color of urine, for even the laity are apt to draw conclusions from this physical sign. Much information may be obtained from a thorough examination. The normal color of urine, which varies from an amber color to a yellowish-red, depends upon the pigment known as Heller's Urophæin [Urohæmatin], or Thudichum's Urochrome, etc. It is to be remembered that articles of diet, drinks, and medicine will greatly affect the normal hue. Strong coffee darkens the urine; a greenish-yellow or brownish tint is observed when rhubarb has been taken; but this hue is also indicative of the presence of bile. Turpentine produces a dark color and imparts the odor of violets to the fluid. Senna produces a yellowish color; indigo, chincaphilia, hæmatoxylon, and beet-root will tint the urine deeply. Tar and creosote, and the external and internal use of carbolic acid render the fluid black, so will disintegrated blood or inhalations of arseniuretted hydrogen. A red color is generally owing to an admixture of blood; a very light color is indicative of an increase of water, found in diabetes, hysteria, and similar nervous affections. A dark urine is found in fever patients; a light-colored fluid is always indicative of the absence of fever.

Now, since the physician is aware of the many causes which may be productive of changing the color of this excretion, he will know the necessity, at the bedside of the patient, of reasoning, by way of exclusion.

If we can not account for the abnormal color by articles of

diet or medicine introduced into the system, we must endeavor to determine its cause. The change may depend upon the coloring pigment *urophæin* (urohæmin). This substance contains iron, and resembles closely the pigment of the blood. Indeed, it is believed by many physiologists to be the product of retrograde metamorphosis of the red blood corpuscles. Many reasons would seem to point to the correctness of this theory. The blood corpuscles certainly undergo changes like all organic substances, and no other excreted material corresponds so well to the product of the changed red blood corpuscles, particularly their haematin, than the urophæin in the urine and the biliverdine in the bile.

The increase of this pigment in all acute febrile affections, but more especially in typhus fever and other diseases dependent upon a morbid condition of the blood, such as is associated with septic poisons, would give support to this theory. Should it become an established fact, the physician will have every reason to place importance upon this particular pigment in his diagnosis and prognosis.

Urophæin is detected in the urine by adding to a specimen double the quantity of sulphuric acid; the result is a brown color, if the mixture become dark, the quantity of urophæin is shown to be increased, which is the case in diseases of the liver, as well as in the affections already indicated.

For the purpose of estimating with accuracy the quantity of this pigment, Vogel has proposed a method of comparing the hue of the urine with a table of fixed colors, which serve as starting points, and each shade of which represents a definite proportion of the pigment. Urine to be thus compared, must be clear (if not so, it is to be filtered) and should be put in a glass beaker of four or five inches diameter. It is to be remembered that all specimens of urine in which the color has been changed by bile pigment, articles of food and medicine, must be excluded from this examination.

The shades of urine have been arranged under three groups, as follows:

I.—*Yellowish Urines:*

1. Pale yellow, like a weak solution of gamboge.
2. Bright yellow, like a medium solution of gamboge.
3. Yellow, like a strong solution of gamboge.

II.—*Reddish Urines:*

1. Reddish yellow, like gamboge with a little carmine.
2. Yellowish red, like gamboge with more carmine.
3. Red, like carmine with a little gamboge

III.—*Brownish Urines:*

1. Brownish red, red with an admixture of a little brown.
2. Reddish brown, more of the brown than in the last.
3. Brownish black, almost black with a touch of the reddish-brown.

The following table, prepared by Vogel, gives an estimate of the quantity of pigment contained in a certain amount of urine of a fixed shade, and also indicates the relative amount of pigment contained in different specimens of urine, of equal quantity, but of various shades.

I*	II	III	IV	V	VI	VII	VIII	IX	*REMARKS.
1	2	4	8	16	32	64	128	256	*I. Pale yellow.
	1	2	4	8	16	32	64	128	II. Bright yellow.
		1	2	4	8	16	32	64	III. Yellow.
			1	2	4	8	16	32	IV. Reddish yellow.
				1	2	4	8	16	V. Yellowish red
					1	2	4	8	VI. Red.
						1	2	4	VII. Brownish red.
							1	2	VIII. Reddish brown.
								1	IX. Brownish black.

For the purpose of making these approximative comparisons, Vogel has fixed the quantity of coloring matter contained in 1000 c. c. of pale yellow urine at one.

Example.—If a certain quantity of pale yellow urine (as compared with the color table), say 1000 c. c., contains one part of coloring matter, the same amount of yellowish red will contain 16 parts, and of brownish black 256 parts. One volume of yellow urine contains as much pigment as four volumes of pale yellow urine. One volume of red urine contains as much as four volumes of reddish yellow, or 52 volumes of pale yellow urine. If one individual discharges 1000 c. c. of yellow urine

in 24 hours, another during the same length of time 4000 c. c. of a pale yellow color, both will have eliminated the same amount of coloring pigment. The following may serve as an example to determine the proportion of coloring matter contained in 1800 c. c. of urine of a "yellow" color.

1000 c. c. of *pale yellow urine* equals one part of pigment. *Yellow urine*, however, contains, according to the above table, *four times more* pigment, we receive, therefore the following proportion :

$1000:4 = 1800:x = 7, 2$; is the total amount of pigment contained in 1800 c. c. of yellow urine, provided the amount in 1000 c. c. of pale yellow urine is fixed at 1.

The other coloring matter named by Heller "*uroxanthine*" or "*indican*" by Schunk, is decomposable by strong acids and heat, into a red pigment "*urrrhodine*" and a blue pigment "*uro-glaucine*" the former identical with indigo-red, the latter with indigo-blue. Uroxanthine is detected by mixing thirty drops of urine with five or six times as much of strong hydro-chloric or nitric acid; the fluid after agitation becomes red or faintly violet; if the fluid contains more than a very small amount of this pigment, the mixture becomes decidedly violet or blue from the development of the indigo. Exposure to air also evolves this pigment; its composition is very similar to that of *hæmatin* and the coloring matter of the bile. It is found in small quantities in normal urine, and increases in the febrile affections, in all concentrated urines, in diseases of the nervous system, kidneys and serous membranes, in cholera, etc. The urine of persons afflicted with melanotic cancer, whether seated in the urinary passages or elsewhere, becomes on exposure to the air gradually brown or even black (like porter); this change may be hastened by the addition of nitric or chromic acid; the color is evidently due to the melanine in the pigment cancer, and may be regarded as diagnostic of that affection. [For particulars see Eiselt in "*Prager Vierteligahrschrift*" 1858, p. 190, and Priban in the same journal, 1865, p. 16.]

The pink color of urine is in most cases attributable to the

coloring matter "uroërythrin." Golding Bird has described a similar pigment as "purpurine"; it is this substance which imparts to the deposit of urates or uric acid the brick-red or pink color. In febrile and liver affections, in acute rheumatism and gout, the quantity of uroërythrin is increased, and gives the urine a reddish hue. A solution of acetate of lead produces a pinkish precipitate, which is its test.

Thudichum supposes this pigment to be a product of oxidated *urochrome*, which latter he believes to be the normal coloring pigment of the urine, and that Harley's *urohæmatin*, Heller's *urrrhodin*, and Schunk's *indigo-rubia*, are nothing more than products of decomposed *urochrome*. Thudichum says "urochrome yields by chemalysis various remarkable products of decomposition—viz., *uromelanine*, *uropittine*, and *omicholine*. Schunk states that the color of the urine is not dependent upon only one pigment, and since new coloring matters will form, by spontaneous decomposition of either the original coloring principle or some other substance contained in the fluid, it is not at all surprising that those pigments are increasing both in name and number. The same observer, as already mentioned, has proven that the *uroxanthine* of Heller, and the product of its decomposition, *uroglaucline* and *uropodine*, are identical with the substance named by him *indican* and its product of oxidation, *indigo-blue* and *indigo-red*; and when it is considered that Thudichum's *urochrome* is the source from which many of the above-named coloring matters are derived, the study of these pigments is much simplified. I shall now consider the tests for *indican* (*uroxanthine*) and *urochrome*.

Indican itself does not impart any color to the urine, but by its decomposition, to which it is very prone (as observed above), it yields indigo-blue, indigo-red, and glucose. Schunk finds it in normal urine, and Carter has proposed the following test: (Da Costa, 3d edit., p. 592). Into a test tube pour urine to the depth of half an inch; add one-third of its volume of commercial sulphuric acid of the specific gravity 1830, by allowing it to trickle down the side of the tube, so as to form the lower

stratum. The fluids should then be intimately mixed by agitating them together. There is produced, according to the amount of indican present, a color varying from the faintest tinge of pink or lilac to the deepest indigo-blue. Unless due regard be paid to these minutiae, the reactions mentioned will not be observed. A tolerably correct estimate of the share taken by the different coloring matters in the production of a given tint may be made by neutralizing the sulphuric acid, added as above, with caustic ammonia, then agitating the mixture with one-third of its volume of *ether* and allowing it to remain at rest for a few minutes. The ether rises to the surface, holding the indigo-red in solution, and the blue in suspension (if any have been generated), leaving the ordinary urine pigment dissolved in the aqueous fluid below. The following is a test recommended by Thudichum for the detection of *urochrome*.

1. Fresh urine is treated with excess of milk of lime or baryta, allowed to stand, and filtered. To the filtrate, lead acetate with a little ammonia is added till colorless, and the precipitate well washed and digested with cold dilute sulphuric acid, till a filtered sample shows an excess of sulphuric acid when tested with barium chloride and hydrochloric acid. At this point filter the whole, shake the filtrate with barium carbonate to remove the sulphuric acid, add a little baryta water, pass carbonic acid through the liquid, and filter again. Precipitate the solution with mercuric acetate, wash the precipitate of *urochrome* mercury very thoroughly with cold and hot water, decompose it by sulphuretted hydrogen, filter, shake the filtrate with a little fresh silver oxide to remove hydrochloric or kryptophanic acid, filter; again decompose by sulphuretted hydrogen, and evaporate the filtrate to dryness in *vacuo* over sulphuric acid. A yellow uncryallizable mass of *urochrome* remains.

2. *Urochrome* is easily soluble in water with a yellow color, very little soluble in alcohol, soluble in *ether*, and can thereby be separated from kryptophanic acid, which is insoluble in *ether*.

3. To the solution in water, add lead or mercuric acetate; a flaky yellowish precipitate will fall.

4. Add silver nitrate; a gelatinous precipitate soluble in nitric acid will form.

5. Add mercuric nitrate; a white precipitate, pale, flesh colored on boiling will be produced.

6. The aqueous solution on standing becomes red and deposits resinous flakes, containing uromelanine, uropittine, omicholine, and omicholic acid (q. v.). This decomposition is hastened by boiling and by acids.

7. Treat acidified extract of urine by ether, and distill the latter. Precipitate the residue by basic lead acetate, decompose by hydrothion, and treat urochrome as above.

8. Separate kryptophanic acid by dissolving its lead salt in excess of lead acetate, in which urochrome lead is insoluble.

The colors produced by an admixture of bile or blood will be considered under separate heads in subsequent papers.

The odor may also be taken into consideration in the examination of urine, depending as it does upon its normal or abnormal constituents. Medicines may impart their odor to the fluid, as saffron and cubeb, for instance. After the internal use of turpentine, the odor of violets is perceived. Several French pathologists (DeBeauvais, etc., etc.,) assert that the odor of these articles is not observed in the urine of patients suffering from an organic lesion of the kidneys. This would be a valuable aid in differentiating organic lesions from mere functional disturbances. But Vogel advises us to be chary with this diagnostic sign, as he found the characteristic odor of turpentine in a case which afterwards terminated fatally, and in which examination revealed disease of the parenchyma of the kidney. In cases where but one kidney is affected, the test, in my opinion, would be equally unreliable.

Asparagus and garlic, when taken into the system, produce a most disagreeable odor of the fluid, particularly when indulged in for a succession of days. The laity not knowing this fact, may seek medical advice, fancying a loathsome disease of the kidneys. An instance of this kind occurred last summer in the practice of Professor Morgan, of this city. When urine

has been long retained in the bladder, the odor of ammonia may be perceived. The smell of stale fish is occasionally noticed, and is owing to a slow decomposition of the organic constituents of the urine. A strong urinous smell indicates a large amount of urea or its product, carb. of ammonia; a sweetish odor, like whey, is indicative of *diabetes mellitus*.

SPECIFIC GRAVITY.

To ascertain the density or amount of solid matters contained in urine, the physician generally employs the *urinometer*—although not being the most exact mode, it answers very well. To insure a more reliable result, the fluid should be brought to the temperature at which the urinometer was graduated (generally 60° F.). Mr. Uckland calculated the following table, by which this objection is partly overcome :

Temperature.	Number to be added to the indication.	Temperature.	Number to be added to the indication.	Temperature.	Number to be added to the indication.
60	.00	69	.80	78	1.70
61	.08	70	.90	79	1.80
62	.16	71	1.00	80	1.90
63	.24	72	1.10	81	2.00
64	.32	73	1.20	82	2.10
65	.40	74	1.30	83	2.20
66	.50	75	1.40	84	2.30
67	.60	76	1.50	85	2.40
68	.70	77	1.60	86	2.50

Example.—Suppose the urinometer to float in urine of 73° temperature at 21. On referring to the table, opposite 73° will be found 1.20, which is to be added to the indication 21, making the true specific gravity $21 + 1.20 + 1000 = 1022.20$.

The specific gravity is best taken by measuring 100 c.c. of urine into a beaker or flask, whose weight is accurately known. The increase of weight in grains will be the specific gravity, water being 1000. Instead of 100 c.c., 20 or 25 may be taken, when the weight multiplied by 2 or 4, will be the specific grav-

ity. [Sutton.] From the specific gravity we can calculate the total amount of solid matter contained in any given quantity of urine by multiplying the number above 1000 by 2 for the specific gravity below 1018, and by 2.33 for those above. We can thus calculate the whole amount of solids contained in the urine passed during twenty-four hours, provided we know its weight and its specific gravity. In urine of a specific gravity of 1010, there would be 20 grains of solid matter in each 1000 grains, and in urine of 1030, 69.90 grains. If 1000 grains of urine [specific gravity 1016] yield 32 grains of solid matter, how much would 18,000 grains [the amount passed in twenty-four hours] yield? $1000:32:18,000$ x. $x = 576$ grains.

This method is not very precise; where exactness is required, the urine is to be evaporated to dryness, and the dry residue carefully weighed, or proceed as follows:

(1.) Measure 5 c.c. into a shallow porcelain or platinum capsule; (2) place it beside a vessel of strong sulphuric acid under a receiver of a powerful air-pump, and keep it in *vacuo* till all moisture is removed. The total amount of solid matter (including organic and inorganic substances) excreted by the kidneys in twenty-four hours, is rated by Golding Bird at 650, or between 600 and 700 grains; by Beale and others, it is rated at between 850 and 1020 grains. The total amount of the saline matter in urine is estimated by the following process recommended by Neubauer: A measured quantity of urine, 20 to 30 c.c., is evaporated in a porcelain crucible of ascertained weight by means of the water-bath. When the residue has become nearly dry, from one to two grammes [15 to 20 grains] of finely powdered and carefully weighed spongy platinum are mixed with it by aid of a small platinum wire, and the whole is then evaporated to dryness. The residue, with the platina, is then heated over a spirit lamp, at first very gently, and then more strongly, until the whole of the carbon in it is consumed and the residue has assumed a light gray color. By subtracting the weight of the crucible and of the spongy platinum, we obtain the amount of the incombustible salts in the urine.

The following is Sutton's mode: (1.) Measure 10 c.c. of urine in a small porcelain crucible; (2) evaporate to dryness; (3) add about ten drops of nitric acid; (4) heat the crucible to dull redness; (5) suffer it to cool, and add ten more drops of nitric acid; (6) heat it up again gradually to a moderately strong heat, until all the carbon is destroyed, and the residue is white; (7) let it cool and weigh.

What are the indications of a high or low specific gravity?

In proceeding to answer this question, I must again call attention to the great fluctuation in the specific gravity of normal urine. I have pointed out in my previous paper (pp. 9-10) the numerous causes which may influence the specific gravity. In this and all the other examinations of urine, we are only then benefited and guided when we observe well and reason better.

We must, above all, take into consideration the quantity of urine passed in the twenty-four hours, the amount of food and drink taken into the system, and the weight and age of the patient. If the quantity of urine is less than the average, and the specific gravity higher than normal, no inconsistency exists; and since the specific gravity of urine depends upon the amount of solids contained therein, and these again upon the amount of tissue metamorphosis, and the food taken into the system, we can readily understand why the specific gravity of urine is high in all affections characterized by great destruction of tissue; and that the character of food, particularly if it consists of highly nitrogenous substances, will influence the specific gravity, by the presence of an increased amount of urea.

The weight of the body must be taken into consideration, inasmuch as a patient of large weight may not discharge more urine in the twenty-four hours than one of considerably less weight; but would not the quantity of solid matter, in obedience to physiological laws, be more in the former than in the latter case? The variation of the specific gravity in age explains itself, if we remember the source of the solid constituents.

As the specific gravity is greatly influenced by the amount of urea (excluding of course diabetic urine), the physician can assume that the rise and fall of the specific gravity corresponds to an increase and diminution of this important constituent. Often, however, the specific gravity is low, owing to the retention of this substance in the system.

The specific gravity is high in urine of a deep color, seen in the acute febrile affections, particularly during the violence of fever. The quantity of urine in these cases is generally diminished.

In diabetes mellitus the specific gravity is high, 1030 or more; also after the administration of saline diuretics; in both the quantity of urine is increased. The specific gravity is low in certain forms of Bright's disease, in hysteria, and all pale urines, excepting that in diabetes mellitus.

RE-ACTION OF URINE.

We have seen, in speaking of normal urine in the previous paper, that it reddens blue litmus paper, showing its acid reäction, that this was due to its acid salt (the bi-phosphate of soda), and that the degree of acidity varied greatly. If no food has been taken into the system for hours, it becomes highly acid; that passed after meals, or while digestion is still going on, is but faintly so; it may be neutral or even alkaline. Dr. Jones found that the acidity of urine was not augmented by continued fasting, for after twelve hours or so no increase in the acidity could be observed. There are many causes which may disguise the true reäction of this fluid. Thus the urine may be alkaline when excreted, but being mixed in the bladder with an acid urine, becomes neutralized, if not acidified; or urine may be acid when secreted, and meeting in the bladder an alkaline urine, will assume a similar property. For the cause of alkalinity of urine after meals, and its normal acid reäction, we must, according to Roberts and Vogel, look to the blood. (See p. 16).

The different mineral and vegetable acids, when introduced

into the system, will increase the acidity of urine. An acid urine is of importance to the physician only when, by a quantitative analysis, it has been ascertained that the amount of acid exceeds the normal proportion.

The acidity of urine is very strongly marked, if an acid (lactic, oxalic or kryptophanic*) be present, which will separate uric acid from the ammonia with which it is combined, or if the uric acid be in decided excess.

The amount of free acid is measured by a solution of carbonate of soda, containing 530 grains in the 10,000 grain measure = 53 grammes in the litre; and is represented by determining how many grains of crystallized oxalic acid a certain quantity of the soda solution will neutralize.

The details of the process are as follows: 1. Take 50 or 100 c.c. of perfectly fresh urine; (2) add from a burette a standard solution of soda, in small portions at a time, say 5 c.c. or drop by drop; (3) after every addition, test the fluid, by moistening a thin glass rod or feather with the mixture, and streak it across some well prepared violet litmus paper; when the streaks cease to become red, the analysis is complete; (4) estimate how much of a standard solution has been used, and express the acidity as equal to so many grains of crystallized oxalic acid.

Note on Kryptophanic Acid.—Thudichum, in 1870, announced that he had discovered a free acid in normal urine and named it kryptophanic acid [$C_5 H_9 NO_5$ or $C_{10} H_{18} N_2 O_{10}$]. He considers it the principle of the so-called extractive matters, and recommends the following mode for its detection:

1. Evaporate fresh urine to one-third; mix with excess of milk of lime or baryta, allow to stand for a few hours and filter; acidify the filtrate with acetic acid, evaporate to a syrup, and set aside to crystallize. Separate the crystals by draining and pressure from the mother liquor; add to the latter five times its volume of alcohol, of 90 per cent., shake well, allow to stand for five minutes; pour off the liquid, and wash the pre-

* For Kryptophanic acid, see note on this page.

cipitate with a little more alcohol. Warm the sticky deposit to drive off the adhering alcohol, dissolve in a small quantity of water and filter. To the filtrate add twice its bulk of saturated solution of lead acetate, filter from the dark brown precipitate, mix the filtrate with three volumes of 90 per cent. alcohol, wash with alcohol the nearly white precipitate of lead kryptophanate; lastly, wash with a little absolute alcohol, dry at 100° C. and weigh.

2. Mix with water to a thin cream, and for every 100 parts of the dry salt, add an equal weight of sulphuric acid, containing 25 per cent. of H_2SO_4 . After standing for some time, with frequent agitation, filter and test a portion of the filtrate for sulphuric acid; if any be present, precipitate it out exactly with baryta water, adding no excess, and filter. Evaporate the filtrate to a thick syrup, precipitate with 90 per cent. alcohol, wash the precipitate with a little more alcohol, and dry the pure kryptophanic acid at a very gentle heat, or in vacuo.

3. The acid is very soluble in water, nearly insoluble in alcohol, insoluble in ether.

4. Dissolve a portion in water; the solution has a pleasant acid taste. Use it for the following experiments:

5. Add a little saturated lead acetate solution; a white precipitate will fall, redissolved by excess, and again precipitate by alcohol.

6. Add copper acetate; a green precipitate will form, behaving like the lead compound.

7. Dry a portion of the green precipitate at 100° C., and distill with a small quantity of water. The substance will turn dark green, and alcohol will be found in the distillate, proved by a diminished specific gravity, and by its reducing a drop of potassium bichromate and sulphuric acid.

8. Add copper sulphate in excess, then excess of caustic potash. If, "on long boiling," the copper is reduced, the acid is yet impure; the pure acid does not reduce copper solution.

9. Add mercuric nitrate, or acetate, or silver nitrate; a white precipitate will fall, soluble in nitric acid.

10. Add ammonio-nitrate of silver; the solution will become dark, and will gradually deposit black metallic silver.

11. Heat a kryptophanate in the solid state, on platinum foil; acid vapors are perceived, but no urinary smell, and a residue of almost incombustible charcoal remains.

12. Add barium or calcium chloride; no precipitate. Add ferric chloride; a brown precipitate will fall, soluble in excess or in ammonia, deposited again on boiling.

Intense acidity of urine may favor the formation of sediments or concretions of uric acid in the bladder, and frequently causes irritation and inflammation of the urinary passages. The alkaline treatment is to be pursued in these cases.

It has been frequently observed that a specimen of urine may respond, by the litmus-paper test, both to an acid and alkaline reaction. [Neubauer and Vogel's Anleitung, 6th edition, Wiesbaden, 1870, page 257.] This paradoxical phenomenon is explained by Vogel as follows: In the beginning of alkaline fermentation, the developed ammonia may unequally diffuse itself in the liquid, and render only some parts alkaline; or it may form, above the level of the fluid, an ammoniacal sphere, while other portions of the same fluid still retain sufficient phosphate of soda to render them acid in reaction.

Healthy urine generally remains acid for twenty-four hours. Should it lose its acidity sooner, it signifies almost as much as if the fluid had been discharged in a neutral or alkaline state. For the physician to attain reliable results, he must be satisfied that the fluid about to be examined was voided within twenty-four hours, that the vessel was clean and free from all impurities, and that it has not been added to a urinal containing portions of an alkaline urine. He should, according to Sir Henry Thompson, direct his patients to pass first two ounces into one vessel, and the remainder separately.

It is a well known fact that, if a specimen of urine of acid reaction is added to an alkaline or neutral fluid, both will lose their characteristic reaction, and hence are unreliable for

examination. The urinals must be perfectly clean, and should be washed as soon as the urine has been examined.

The alkaline reäction of urine, in health, was stated to be due to the process of digestion or a fixed alkali, like carbonate of potassa or soda, depending upon the introduction of articles of diet, such as vegetables, or the citrates, malates and tartrates into the system.

If red litmus paper be immersed into an alkaline urine (produced as above), it turns blue, and remains so when dry. A glass rod, previously moistened with hydrochloric acid and held above the surface of the urine, produces no white nubecula.

This alkalinity of urine is not inconsistent with health; but, if it continues for any length of time, kept up by an undue introduction of articles containing alkalies, or substances convertible into such, into the system, and especially if the urine exhibits sediments of the *earthy phosphates* soon after it has been discharged from the bladder, the physician must interdict their use, lest it may lead to the deposit of these phosphates within the urinary passages.

The alkaline reäction produced by the presence of volatile alkali, due to the decomposition of urea into carbonate of ammonia, is always to be viewed as pathological.

In this condition of alkalinity, the red litmus paper turns also blue, but the original red tint is restored as soon as the paper becomes dry. A glass rod, moistened with hydrochloric acid and held above the surface of the urine, will evolve white nubeculae.

"In alkalescence from either cause, the earthy phosphates are precipitated, the fixed alkali causing the precipitation of the amorphous phosphate of lime; while by the volatile alkali, the phosphates of ammonia and magnesia, in conjunction with the phosphate of lime, are thrown down, and the triple phosphate is abundantly formed, and can be easily recognized under the microscope by its beautiful prismatic crystals."—(Da Costa.)

I have partly pointed out the pathology of this kind of

alkaline urine, in speaking of alkaline fermentation, and I here repeat that the urine loses its acidity in the bladder, owing to fermentive processes which may be going on there under certain circumstances. We see this in paraplegia, in paralysis of the bladder, and in diseases of the lining membrane of the urinary passages; the large amount of mucus or pus, the favorable temperature, together with a retention of this fluid in the bladder, will soon lead to the decomposition of urea into carbonate of ammonia, and the consequent alkaline reaction of the urine.

This condition of alkalinity of urine is often very troublesome and long continued. If the mischief is owing to a long retention of the urine in the bladder, as in paralysis, etc., the treatment should consist in drawing off the urine three or four times a day.

If the alkalinity be produced by an admixture of mucus or pus, as in catarrhal and inflammatory affections of the lining membrane of the urinary passages, and the inflammatory process induced (as it most frequently is) by an intense acid condition of the urine, or concretions of uric acid, the treatment must consist of demulcents, as flaxseed tea, with the addition of either the carbonate or acetate of potassa. Nothing, however (as Vogel very justly remarks), is more common than the administration of acids in all cases of alkaline urine. The physician calls this "*rational treatment*" and "*physiological therapeusis*;" but does he not ignore the cause by pursuing such treatment indiscriminately? Surely an acid is not indicated when intense acidity of the urine has caused the mischief; the urine in these cases is frequently acid, when secreted by the kidney, and is only changed (as in cystitis) during its retention in the bladder.

We often meet an alkaline urine from a fixed alkali, with large sediments of the earthy phosphates, and we can not account for this condition, either in the above way or by an undue introduction of alkalies into the system. This is indicative of a serious affection, commonly known as the "*phosphatic dia-*

thesis." I shall speak more fully on this subject, under the phosphates, in a subsequent paper.

"INCREASE AND DEFICIENCY OF UREA."

We have learned (see page 4 of this volume) the source of urea, that it is the product of nitrogenized substances, that the average quantity eliminated by an adult in 24 hours is 500 grains, and that the amount was influenced by the food partaken of, as well as by mental and bodily activity.

All influences which tend to produce destruction of tissue will cause the quantity of urea to be increased. If a sufficient amount of nitrogenous food be taken into the economy, and there assimilated so as constantly to rebuild the broken down tissue, nothing is lost; but if either of these conditions be not fulfilled, wasting of the body follows.

The physician, in making deductions from the amount of urea excreted by his patient, must take into consideration its fluctuations in health, the weight, age and sex of the patient, and never forget that the same causes which tend to increase and diminish its quantity, in health, may still operate in disease. [See p. 4 of this volume.]

An abnormal amount of urea becomes the index of the amount of destruction of tissue, or disassimilation; we find this in all inflammatory diseases and fevers, hand in hand with the emaciation of the patient; also, in certain forms of dyspepsia, in which the food is speedily passed off in the shape of urea instead of acting its part in the nutrition of the economy. These cases of "Azoturia," Dr. Sieveking described in the pages of the "British Medical Journal," in May, 1865; they are characterized by a large amount of urea, without increase in the quantity of urine; no febrile reäction, but languor, weakness, nervousness, associated sometimes with mental anxiety or sexual excess. They are apt to pass into diabetes mellitus.

In the acute febrile affections (pneumonia and typhus), the amount of urea increases, with the violence of the fever, to

670, 900 or even 1200 grains in the 24 hours. With the abatement of the fever, the amount is often diminished to 200 or 250 grains in 24 hours. During convalescence, and with the return of the appetite, it gradually increases until the normal standard is reached. In intermittent fever, it is increased during the paroxysm, and even before and during the cold stage, which rather supports the theory of actual fever during that stage. I may mention here that Vogel has not always found an increased elimination of urea to go hand in hand with the elevation of the temperature in fevers, etc. But it can not follow that, because the amount eliminated is not abnormal, there is no increase, since, as will be presently shown, a retention of this substance in the system may take place.

A deficiency of urea in the urine indicates either a decrease of tissue changes, as in long continued organic diseases; it may be due to an insufficient supply of nitrogenous food, or to a want of power of the kidney to eliminate urea; in the latter case, retention and accumulation of this substance in the system is the result, and the train of symptoms known as "uræmic poison" will follow. Some, physiologists maintain that the retained urea is decomposed into carb. of ammonia, and that it operates as such, as a poison. The experiments of Professor Hammond and others seem to disprove this hypothesis. It matters little whether it is the urea or its product, carb. of ammonia, the symptoms remain the same; they are characterized by nausea, headache, convulsions and coma. Dr. Flint believes that the occurrence of these symptoms during or subsequent to scarlatina with renal complications, in nephritis and in Bright's disease, are owing to uræmic poison. It is stated, and upon good grounds, that a form of puerperal convulsions originates from the retention of urea in the blood, it being produced by the pressure of an impregnated uterus upon the renal arteries.* Flint also points out the development of amaurosis and in-

* This condition may eventuate in Bright's disease; Dr. Busey on the induction of artificial labor in uræmia.

flammation of serous membranes as results of uræmia; and that it stands in causative relation to pneumonia. Persistent vomiting and purging belong to the clinical history of uræmia; nature endeavors, so to speak, to rid the system of a poison through the gastro-intestinal membrane. We may suspect the existence of uræmia from the inadequate amount of urea excreted, from a low specific gravity of the urine, or suppression of the same, and may be positive of it from the concurrence of headache, nausea, vomiting, convulsions and coma.

Not infrequently urea is diminished in the urine or entirely absent, having been replaced by tyrosine and leucine. This condition is less significant to the physician, and is not apt to be followed by any serious consequences. I shall devote a few words to leucine and tyrosine further on.

Estimation of Urea.—A rough way to estimate the quantity of urea, is to drop nitric acid into a porcelain capsule holding urine which has been evaporated to a mucilaginous consistence. Crystals of pearly lustre, which the microscope at once shows to be nitrate of urea, are developed, and by always evaporating the same quantity, and using a capsule of equal size, we may judge the amount of this important ingredient, as compared with that contained in other specimens of both normal and abnormal urine. If crystals form without the urine being concentrated by evaporation, simply on the addition of about an equal bulk of nitric acid, urea is always in considerable excess. The deep yellow color, the strong urinous smell, together with a high specific gravity, will often alone convince us of its presence in abnormal quantity.

The subjoined table (page 44), devised by Prof. Sam. Haughton, will give approximately the quantity of urea eliminated in the urine in twenty-four hours, if the number of ounces and the specific gravity have been previously ascertained. The table is one of double entry. When the daily excretion of urine in fluid ounces and its specific gravity are known, at the intersection of the corresponding columns the excretion of urea is

given in grains. The table answers all practical purposes, and is reliable, except when sugar or albumen is present.

I.—*The following Mode of Estimating the Urea in urine is based on the combination which forms between urea and oxide of mercury in neutral or alkaline solutions. The method was devised by Liebig. The precipitate which is formed is insoluble in water, or in weak alkaline solutions. The standard test solutions—viz., "the standard solution of nitrate of mercury," and the "baryta solution," are required; and the indicator which shows when all the urea has entered into combination with the mercury, and when the latter predominates, is a solution of carbonate of soda. The method of procedure is thus given:*

(1.) Take one volume of the baryta solution (20 c.c.) [obtained by mixing one volume of a solution of nitrate of baryta with two volumes of a caustic baryta solution, both prepared by cold saturation,] and mix with two volumes of urine (40 c.c.). [The precipitate may be reserved for determining the phosphoric acid]; (2) after filtration, take 15 c.c. of the fluid (= 10 c.c. of urine) for each analysis, in small beakers; (3) bring the beaker under the burette containing the mercurial, solution (the strength of this solution recommended is such that 20 c.c. of the solution exactly suffice for the precipitation of the urea in 10 c.c. of a standard solution of urea, in which this quantity of fluid contains precisely 200 milligrammes of urea), which is to be added in small quantities so long as a distinct precipitate is seen to form, the mixture being stirred constantly; (4) a plate of glass or porcelain is now to be sprinkled with a few drops of the solution of carbonate of soda, and a drop of the mixture brought from time to time in contact with the drops of soda-solution by means of a glass rod. So long as the mixture of the two drops thus brought together remains white, free urea is still present in the mixture, and more of the test solution must be added to the urine till the contact of the drops with the soda-solution produces a yellow color, which is distinctly apparent; (5) record the quantity of mercurial test

solution used, and so calculate for the amount of urea contained in the 10 c.c. of urine, and hence in the total discharge for twenty-four hours; (6) repeat the analysis at least twice; if albumen is present, coagulate it by exposure to heat, and remove by filtration before testing for urea.

II.—*Estimation of Urea based upon Liebig's Method*, closely allied to the above. [Thudichum.] (1.) Dissolve in a beaker 100 grammes of pure mercury in about 500 grammes of pure nitric acid; add a further quantity of nitric acid in drops, gently shaking occasionally, until no red vapors are evolved either on the addition of nitric acid or on shaking; then evaporate the solution at a gentle heat until it is a colorless syrup. Care must be taken that none of the liquid is lost by spouting.

(2.) Dilute the solution to exactly 1400 c.c., adding a little nitric acid to prevent the formation of an insoluble basic salt. This forms the standard solution of nitrate of mercury, each cubic centimetre of which represents a centigramme of urea. To be certain of its strength, a test experiment should be made by estimating a known quantity—about two decigrammes—of pure urea, as described hereafter.

(3.) Prepare cold saturated solutions of baryta water and barium nitrate; mix two volumes of baryta water with one volume of nitr. of barium solution. This mixture forms the baryta solution used in the analysis.

(4.) On a glass plate, under which is a piece of white filter paper, place a number of small drops of carbonate of soda solution.

(5.) Add to 30 c.c. of urine 15 c.c. of the baryta solution; mix well with a stirring-rod, and filter through a dry filter paper. Measure off 15 c.c. of the filtrate ($= 10$ c.c. of urine) into a small beaker, add the standard nitrate of mercury solution from a burette or other graduated vessel until a drop of the mixture, when added to a drop of carbonate of soda solution on the glass plate, produces a distinct yellow color in two seconds. When this color appears, read off the number of cubic centimetres used; each centimetre required indicates one

centigramme of urea in the 10 c.c. of urine. Thus, if 25 c.c. of mercury solution were used, there would be 25 centigrammes or 0.25 gramme in 10 c.c., or 25 grammes in the litre.

Another method has been recommended by Dr. Edmund W. Davy ("Phil. Mag.", vol. vii., 4th series, p. 385). The process is based on the fact that urea is readily decomposed by hypochlorite of soda (Labarraque's solution), when the nitrogen being evolved as a gas, the amount of urea is estimated from the amount of nitrogen gas produced by the decomposition. A strong glass tube, about fourteen inches long, closed at one end, and its open extremity ground smooth, is required. The bore of the tube must not be larger than the thumb can conveniently cover—i. e., half an inch in diameter. It ought to be graduated into cubic inches, commencing from the closed end, and each cubic inch again subdivided into tenths and hundredths.

The following are the details of the process: (1.) Fill the tube more than one-third full of fluid mercury; (2) pour in carefully half a fluid drachm to one drachm of urine; (3) holding the tube in one hand near its open extremity, and having the thumb in readiness to cover the aperture, quickly fill it completely full with a solution of hypochlorite of soda (taking care not to overflow the tube), and then instantly cover the opening tight with the thumb; (4) rapidly invert the tube once or twice to mix its contents; and (5) finally open the tube under mercury contained in a strong cup or small mortar. (6) the tube is left in the upright position till the evolution of gas ceases, which it generally does in from three to four hours; (7) record the amount of gas found, and estimate the urea by the following data: 1.549 cubic inches of gas represents one grain of urea.

The hypochlorite of soda used should always be five or six times the volume of urine operated upon. The liquor sodae chlorinatae of commerce always gives erroneous and exaggerated results. With the imported French solution, the result is gratifying and reliable.

SPECIFIC GRAVITY.

	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028		
20	35	43	57	71	85	100	108	116	124	130	136	142	151	160	166	176	182	190	196	205	211	249	255	265	274	276	279	280
21	22	38	45	59	74	85	95	110	113	116	130	143	149	156	166	176	182	190	196	205	215	245	253	261	274	292	294	292
22	23	40	41	49	62	81	97	113	118	121	136	149	156	163	173	184	192	205	216	226	236	256	265	276	288	292	294	292
23	24	42	43	51	68	85	101	120	123	127	142	156	163	170	171	177	188	200	205	215	225	236	249	262	281	293	306	308
24	25	43	45	53	71	88	106	125	129	132	147	162	170	177	188	200	205	215	225	236	249	262	281	293	313	334	336	
25	26	45	47	55	73	92	110	130	134	137	153	169	176	184	196	208	214	226	236	249	262	281	293	313	334	356	360	
26	27	47	49	57	76	95	114	125	139	143	159	175	183	191	213	216	264	314	325	326	347	359	369	372	374	376	378	
27	28	47	49	57	76	95	114	125	139	143	159	175	183	191	213	216	264	314	325	326	347	359	369	372	374	376	378	
28	29	48	49	59	79	99	118	140	144	148	165	182	190	198	221	224	274	320	337	349	360	372	388	396	398	399	392	
29	30	50	52	61	82	103	122	145	153	171	188	197	205	228	232	284	337	349	361	373	386	397	400	402	404	406	406	
30	31	54	55	66	85	106	127	150	155	177	195	204	213	226	240	294	346	361	374	386	398	411	414	416	418	420	420	
31	32	54	55	66	85	106	127	150	155	177	195	204	213	226	240	294	346	361	374	386	398	411	414	416	418	420	420	
32	33	55	56	67	88	106	125	150	160	164	182	201	210	220	235	248	303	361	373	386	398	411	425	428	431	434	434	
33	34	57	58	68	90	113	135	160	165	169	188	208	217	227	241	256	313	373	385	397	411	424	438	452	455	457	460	
34	35	60	61	72	96	120	144	170	175	180	200	221	231	241	256	272	323	396	409	423	437	451	466	476	477	478	478	
35	36	61	64	76	99	127	153	180	185	191	212	234	244	255	271	288	352	419	433	448	462	477	493	507	510	513	516	
36	37	63	66	78	105	130	157	185	190	196	218	240	251	262	276	362	450	445	461	476	490	507	510	513	516	518	520	
37	38	65	68	80	106	134	161	190	195	201	224	247	258	269	286	304	372	432	457	473	488	503	520	524	527	530	532	
38	39	67	70	82	111	138	166	186	195	204	230	253	265	276	294	312	382	453	469	486	501	516	534	538	541	544	546	
39	40	69	72	85	114	142	170	200	206	212	236	260	272	284	302	320	392	465	482	498	514	530	548	552	555	558	560	
40	41	71	74	99	124	148	175	200	227	258	280	316	346	361	394	407	476	540	546	546	547	548	552	555	558	558	558	
41	42	74	75	98	119	148	178	210	226	257	285	317	347	376	408	437	506	522	537	552	567	575	580	582	585	585	585	
42	43	75	76	99	122	152	182	215	232	265	293	323	354	384	414	443	513	533	553	570	589	593	596	599	602	605	608	
43	44	76	78	98	125	156	186	220	226	233	259	286	312	342	372	402	473	543	560	578	594	603	616	621	624	627	627	
44	45	78	80	97	120	153	186	216	236	248	271	299	326	357	386	416	450	523	542	561	579	597	616	630	635	638	641	
45	46	80	82	98	123	156	186	216	236	248	271	299	326	357	386	416	450	523	542	561	579	597	616	630	635	638	641	
46	47	82	84	99	123	156	186	216	236	248	271	299	326	357	386	416	450	523	542	561	579	597	616	630	635	638	641	
47	48	84	86	99	123	156	186	216	236	248	271	299	326	357	386	416	450	523	542	561	579	597	616	630	635	638	641	
48	49	84	86	101	136	166	195	230	250	271	299	326	357	386	416	450	523	542	561	579	597	616	630	635	638	641	641	
49	50	84	86	103	139	174	201	221	241	266	278	291	319	328	341	401	477	494	516	527	545	562	566	568	571	574	574	

I have dwelt somewhat at length upon this subject, and endeavored to give the different methods for the estimation of urea. I hope the physician will not find them difficult of execution. The study of urea seems to me highly important. Perhaps many cases of unexpected death, and deaths from undetermined causes, might have been explained had the urine been examined.

The Therapeutical Indications in uræmia are: Promotion of its excretion by the kidneys and to favor its vicarious elimination by cathartics, warm or hot baths, etc.

Most physicians are aware in our days of the theory advanced by Simon, Lehman, Brown-Séguard, and others, that the kidneys defibrinate the blood. I have seen this theory satisfactorily demonstrated by Professor J. H. Thompson, of this city. It is claimed that the kidneys destroy a certain quantity of fibrin daily, and that, since its quantity is not diminished in the blood, a fresh supply must be constantly formed elsewhere. What becomes of the fibrin during its passage through the kidneys is a question yet to be determined. It is certain, however, that it is not discharged from the system as fibrin, since it has not been detected in normal urine.

The practitioner who has accepted the above theory, has also, in many instances, adopted the treatment suggested by it; looking upon the kidneys as defibrinators, he has whipped up these organs a little more than he otherwise would have done.

While I admit the philosophy of such treatment in all cases where the kidney is not itself affected, I can not refrain from saying, that these organs, when diseased, are only too often overworked by diuretics. I have every reason to believe that the physician, in treating Bright's disease, will meet with success, if not in curing the lesion, certainly in prolonging life far beyond the usual period, by giving the diseased kidneys that rest which is so essential in the treatment of all inflamed organs, and by favoring the vicarious elimination of urea, etc.

CREATINE AND CREATININE.

I have previously described these substances, and stated that their source was in the disintegration of muscular tissue. I shall here mention, that an increase of both is noticed in urine during continued animal diet, active muscular exercise, in acute affections—pneumonia, typhus, and intermittent fever. Several observers, as Voit, Navorocke, and Meissner, found that increased muscular exercise, without disintegration of muscular tissue, produces no increase in the amount of creatinine; and the observations of H. Senator on this constituent in the urine of two cases of tetanus, published in Virchow's "Archive," Bd. 48, only confirms their statement. Hoffmann states that pure local affections do not influence the quantity. He noticed an increase in the febrile affections, hand in hand with the emaciation of the patient.

The quantity, according to the same observer, was diminished during fasting, in a faulty nutrition of the system, and during convalescence from acute affections.

The separation of creatine and creatinine is effected by the following process, proposed by Liebig: Treat the urine with lime-water and chlor. of calcium to precipitate the phosphates, filter the liquor and separate the crystalline inorganic salts by evaporation. Treat the decanted liquor with chlor. of zinc, and allow it to stand for a few days; a mass of crystals will then be obtained, consisting of creatine and a triple compound of zinc and chlorine with creatine and creatinine. Dissolve the crystals in boiling water and treat them with hydrated oxide of lead until there is an alkaline reäction. Remove the oxide of zinc and chloride of lead by filtration; free the fluid from the lead and coloring matter by means of animal charcoal and evaporate to dryness. Treat the residue, which consists of creatine and creatinine, with boiling alcohol, which takes up the creatinine and leaves the creatine. The crystals under the microscope are colorless and beautifully transparent.

INCREASE AND DEFICIENCY OF URIC ACID AND THE URATES.

In speaking of normal urine (page 33 of this volume), we

have seen that uric acid exists in the form of urates, and that its presence can only be determined by adding a strong mineral acid, which decomposes the urates and liberates the uric acid ; this being but slightly soluble, is gradually thrown down in a crystalline form. I have pointed out (page 15 of this volume) that this change takes place, occasionally, only a few hours after the urine has been voided, in consequence of the presence of a free acid (as lactic acid). Hoffmann states that the acid phosphate of soda decomposes the urates.

A deposit of uric acid or the urates should induce the physician to make an examination in order to determine to what extent their deposit is consistent or inconsistent with the amount of uric acid eliminated. A sediment does not always prove an excess of uric acid ; an analysis only will reveal the amount of uric acid present. In this connection I may state, that the deposit may be caused: 1. By an increase of acidity sufficient to take the base from the uric acid. 2. By an insufficient amount of water to hold the urates in solution. 3. By a low temperature, since they are more soluble in warm than in cold weather. A deposit produced by any or all of these three causes, need not contain an excess of uric acid.

The following Tests will enable the physician to estimate the quantity of uric acid :

If the deposit consists of crystalline uric acid, wash dry and carefully weigh it. In order to insure success, it is well to acidulate (as recommended by Neubauer) 200 c.c. of urine with 5 c.c. of hydrochloric acid ; set the mixture aside at a low temperature for about three or four days ; this will give sufficient time for the separation of the uric acid. The deposit is to be treated as above, and the amount compared with that contained in normal urine. The average amount of uric acid excreted in twenty-four hours is about 8.569 grains. The range, according to Parkes, between the maximum and minimum amount is as great as from 20 to 30 per cent.

“The characteristic reaction of uric acid is furnished by the murexide test. A few drops of nitric acid are mingled with

the suspected deposit in a capsule, and the mixture is slowly evaporated nearly to dryness over a lamp; a drop of ammonia is then added, which produces instantly a rich purple—Dr. Prout's purpure of ammonia." [Da Costa.] The microscope is a reliable and ready mode of discriminating the uric acid from the water. The crystals have already been described (pages 4-5 of this volume) as transparent rhomboidal plates, or oval laminae with pointed extremities, and it has been stated that they will vary both in size and form, according to the time occupied in their formation. The urates are seen to be either irregular amorphous particles, needle-like crystals, or round globules of varying size, from which fine needles project.

The following is an Improved Method of Estimating the Uric Acid by Iodine, devised by Dr. De Chaumont, and published by him in 1864. The method is based upon the fact that solution of iodine is decolorized by uric acid in a definite proportion, which appears to be four equivalents to one of uric acid. The solutions required are as follows:

(1) A standard solution of iodine. The alcoholic tincture being liable to change, it is best to dissolve the iodine in water with the aid of iodide of potassium; thus, 6.35 grammes (= 1-20th of an equivalent) of iodine, with 12 grammes of iodide of potassium, are dissolved in a litre of distilled water. Of this solution, 1 c.c. contains .00635 of iodine, and will decompose .0021 of uric acid. If the materials be accurately weighed and measured, it will be unnecessary to graduate the solution; but should this be desired, then the following solutions must be prepared: (2) Of uric acid, 168 grammes are to be dissolved in a litre of water. Of this solution, 12.5 c.c. will completely decolorize 1 c.c. of the solution of iodine; (3) a solution of starch carefully filtered and free from suspended grains.

The Process.—(1) Filter the urine from mucus; (2) acidify the urine, should it be alkaline, with acetic acid; (3) put 10 c.c. into a beaker glass and dilute it to 50 c.c. with distilled water; (4) add 5-10ths c.c. of starch liquor; (5) drop in the solution of

iodine from a burette graduated to 1-10th c.c.; (6) stir each time, and wait till the blue color disappears; (7) do not add more than 1-10th c.c. at a time; (8) when the blue color has remained permanent for an hour, read off the number of c.c. of iodine used, and multiply by .21, which will give the quantity per litre.

Example.—10 c.c. of urine required 3.5 c.c. of iodine.

$$3.5 + .21 = .735 \text{ grammes per litre.}$$

For a more accurate analysis, it is necessary to wait for twenty-four hours, until all the uric acid is decomposed, taking care to add fresh portions of starch from time to time as it becomes converted into dextrine. A correction is then applied as follows: (1) Precipitate the salts with Liebig's baryta solution [see process for urea]; (2) filter and acidify with acetic acid; (3) test with iodine as before; (4) deduct the number of c.c. used after the baryta from the gross amount first used, and from the remainder calculate the uric acid as before.

Example.—10 c.c. of urine took 3.5 c.c. of iodine. 10 c.c. so precipitated, filtered, and reacidified, took .45 c.c. of iodine.

$$\text{Then } 3.5 - .45 = 3.05 \text{ c.c. of iodine.}$$

$$3.05 + .21 = .6405 \text{ grammes in a litre, the net result.}$$

Uric acid, like urea, is the product of the metamorphosis of tissue, and its increase and diminution in disease goes, with few exceptions, hand in hand with urea. In health, it is increased by continued nitrogenous food, and still more influenced by an exclusive animal diet. It is diminished during fasting, and increased after a heavy, indigestible meal. Before pointing out the pathological relation, I should state, that frequently the deposit of uric acid or the urates, either while yet retained in the bladder or soon after the urine is voided, is due to acid fermentation, which may have been going on in the urinary passages. [See page 15.] It is also believed that endosmotic influences may render the urine so concentrated as to permit of the precipitation of uric acid or the urates.

The most frequent cause, however, is an actual increase of the "acid phosphate of soda" (frequently met with in persons

of intemperate habits, or suffering from gastric disorders and hepatic affections). The precipitation of uric acid, either in the kidneys, ureters, or bladder, may become the nuclei for renal or vesical calculi. Persons in whose urine (when voided) concretions of a red color are found, are liable to a "*fit of the gravel.*" The red color is diagnostic of the sediment being uric acid or the urates.

The quantity of uric acid is increased during the paroxysm of intermittent fever, and in most of the active febrile and inflammatory affections. In affections in which the spleen is implicated, it exists in that organ in considerable quantity. In typhus and typhoid fever, variola and scarlatina, it is increased, and decidedly so in pneumonia. The sediments of uric acid or the urates are most abundant in the latter affection from the seventh to the thirteenth day. In cardiac affections, in cirrhosis, leucocythaemia, and rheumatism, it is increased, especially in the latter disease, since the red little granules, visible to the naked eye, form a deposit, soon after the urine is discharged.

Uric acid is diminished in almost all chronic affections, in diabetes mellitus, and the advanced stages of Bright's disease; in fact, in all diseases where the eliminating power of the kidney is interferred with. It is also lessened during the administration of large doses of quinine. During gout, uric acid is not eliminated, but the excretion of urea goes on. Dr. Garrod has proven that in this affection an excess of uric acid exists in the blood, and he regards this morbid condition as sustaining a special causative relation to the phenomena of gout. The question arose, whether this excess was owing to an accumulation from insufficient excretion, or whether uric acid was produced in too large quantity in the system. Both explanations are held applicable by Dr. Garrod. He also believes that a reduction of the alkalinity of the blood will favor the deposition of the urates around the joints. Flint very properly terms this excess of uric acid in the blood, in the form of urates, "*Uricæmia.*"

The Pathology of the Urates is the same as that of uric acid.

They have been described as urates of soda and ammonia, and urate of lime and magnesia. The deposit formed by their precipitation is either of a pink, brick-red, or purple color; sometimes, however, they are brown (clay color) or even white. The simplest test to distinguish them from uric acid, is their solubility when heated, and their decomposition by mineral acids. The microscope shows them either as irregular amorphous particles, needle-like crystals, or round globules of variable size, from which occasionally fine needles project. The latter are commonly supposed to be urate of soda; the globules and crystals urate of soda and ammonia; the fine powder, urate of lime and soda.

But these are not positive facts. We only know that the granular amorphous deposit, until lately called urate of ammonia, actually consists of the mixed urates, especially of urate of soda and ammonia. These amorphous urates may, under the microscope, be mistaken for the phosphate of lime. Acids will decide the question. The phosphate is dissolved by acetic or hydrochloric acid, while the urates are gradually transformed into crystals of uric acid. A deposit of phosphate of lime is often more cloudy and less defined than the urates, and unlike them, not soluble in liquor potassæ. From carbonate of lime, which also occurs in a granular form, both urates and phosphates of lime are distinguished by the effervescence of the carbonic acid which happens on the addition of a strong acid. (Da Costa.)

Urine containing a sediment of urates is generally very acid, or soon becomes so, either from an absolute increase of the uric acid, or in consequence of changes in some of the constituents of urine. I have pointed out (page 15 of this volume) that a free acid may be developed, and Vogel states that the pigments materially influence this production; that the deposition of the urates is often due to an insufficient amount of water to hold them in solution. We can easily satisfy ourselves by ascertaining the amount of urine passed during the twenty-four hours.

If the quantity is normal, the deposit is most likely due to an excess of urates. The atmospheric influence has also been spoken of; it is a well known fact, that the urates are more soluble in warm water than in cold, and that urine well saturated with the urates will permit of their precipitation, as soon as the temperature is diminished, below that of the body. But sediments of urates are encountered irrespective of these conditions. They are met with in pale urine, and without either diminution of water or excess of acidity to account for their presence, the urine being of a faint acid or neutral reäction, and under these circumstances phosphate of lime, or even triple phosphates, may be observed to accompany the urates.

The Therapeutical Indications, whether the deposit consists of an excess of uric acid or of the urates, remain the same. In this as in other conditions, the cause should be ascertained and rectified. When the excess is due to indulgence in animal food, its mal-assimilation, etc., the treatment consists in regulating the diet. When due to defective cutaneous excretion (and very frequently it is), the action of the skin must be promoted by clothing, cold baths in the morning, and friction with horse-hair gloves; the diaphoretics are also indicated. [That defective cutaneous excretion is a fruitful cause of an excess of uric acid in the urine, may be explained by the fact, that the surface of the body rids the system of certain organic matters rich in nitrogen, and that whenever this function is interfered with or arrested, the kidneys are called on to carry these substances off in the form of urates.] The introduction of alkalies into the blood to hold the urates in solution, and a plentiful supply of pure water, are naturally indicated, particularly in the cases where the excess of uric acid is due to metamorphosis of tissue, as in most febrile affections. We can not there attempt to treat the cause or cut short the paroxysms, but must be satisfied to promote proper elimination from the system, and prevent precipitation in the urinary passages. Whenever sediments are known to be caused by "*acid fermentation*" within the system, that cause is to be considered in the treatment. The treatment,

as will be observed, is to prevent the formation of calculi, and as directed to the removal of the prime cause of the lithic acid diathesis.

THE PHOSPHATES.

In speaking of their physiological nature (page 12 of this volume), we learned their source, that they are kept in solution by the acidity of the urine, and that they are deposited as soon as the fluid ceases to be acid ; it can therefore be asserted that the appearance of the phosphates goes hand in hand with a neutral or alkaline condition of this urine.

On pages 4 and 5 of this volume, we pointed out the formation of double salts, due to the decomposition of urea into carbonate of ammonia. We can therefore account for the presence of the triple phosphates in heavy deposits, mixed with mucus or pus in certain conditions of the bladder, as chronic catarrh, retention of urine in low fevers, hemiplegia or paraplegia, from the fact that they are the result of changes which have taken place during the decomposition of urine in the bladder. The causes which may lead to a sediment of the phosphates, are those which produce an alkaline condition of the urine generally; they have been pointed out. (Pages 12 and 13.)

We often find urine alkaline from a fixed alkali depositing phosphates, and we can not account for it by an undue introduction of alkalies into the system. This is the condition so frequently met with in anæmic persons, whose nervous systems are shattered, who labor under great debility and indigestion, and who are depressed by mental toil and anxiety; and these are the cases of whom it was common to speak as exhibiting the "*phosphatic diathesis*."

This condition *may* be due to an excess of phosphates, but most frequently it is the want of acidity of urine, which permits their precipitation. Vogel seems to believe that diminished tissue changes will produce an alkaline condition of the urine. When it is remembered that uric acid is the product of

the metamorphosis of tissue, and that in the cases above referred to, tissue changes must be more or less diminished, the theory is acceptable :

"An excess of the phosphates in these cases may be concealed until a careful analysis has been performed. This happens especially with the alkaline phosphates, the phosphate of soda and the ammonio-phosphate of soda, the proportions of which change in disease much more than do the earthy phosphates, and indicate much more clearly the variations of the phosphoric acid. And, paradoxical as it may appear, the acidity of the urine may be so much augmented by the increase of the phosphoric acid that a very large excess of alkaline phosphates may be present in solution in a highly acid urine."—Da Costa.

The elimination of the phosphates in excess, is either the result of an animal diet, the introduction of phosphates as remedies into the system, or of tissue changes, particularly of the nerve structures. Dr. Bence Jones found an actual increase of the phosphates in acute inflammatory diseases of the nerve structure during the existence of the most marked febrile symptoms, and in fractures of the skull when an inflammatory action takes place in the brain. In rickets and osteo-malacia, the phosphates, particularly the phosphate of lime, are found to be in excess in the urine. The quantity in many acute affections is first diminished and afterwards increased, but the variation is so great that no great value can be attached to it.

The amount of phosphoric acid is stated to be diminished during the course of a maniacal paroxysm, in epilepsy and in melancholia.

Microscopical and Chemical differences between the Earthy, the Alkaline and the Triple Phosphates.—The crystals of the ammonio-magnesian phosphate are perfectly colorless and transparent, and have the form of triangular prisms, generally with beveled extremities, or they may appear as feathery-looking bodies.

The phosphate of lime appears as an amorphous powder, or in round small globules. Both Drs. Roberts and Hassall have

pointed out that it may exist in a crystalline form, and that under the circumstances it is difficult to distinguish it from the stellar forms of crystallization of uric acid; they are, however, invariably colorless, which is an important distinction. The earthy phosphates are readily soluble in acids, even in weak acids like acetic acid. In many specimens of urine they are precipitated by heat, but the addition of an acid soon dissolves them, and thus prevents the turbidity from being mistaken for that due to albumen.

The triple phosphates are found most abundant in alkaline urine, due to the decomposition of urea into carbonate of ammonia. Vogel states that their formation is impossible in urine alkaline from a fixed alkali, and that the sediment in such urine seems to consist entirely of the phosphate of lime.

To determine the proportion of the *earthy* phosphates, a few drops of ammonia are added to the urine, soon a whitish precipitate is produced which is not dispersed by heat. From the quantity of the deposit we may form a rough estimate of that of the "earthy phosphates." But if the amount is to be accurately ascertained, we must employ a graduated glass, separate the precipitated phosphates by filtration, ignite them in a platinum capsule and weigh the ashes. The "*alkaline*" phosphates are not thrown down by alkalies, and, unlike the earthy phosphates, are very soluble in water. They are procured by taking the fluid from which the earthy phosphates have been carefully removed by filtration, and adding to it a saturated solution of sulphate of magnesia.

The Process for the Estimation of Phosphoric Acid is based on the fact that when nitrate or acetate of uranium is added to a solution of tribasic phosphoric acid, containing acetate of ammonia and free acetic acid, the whole of the phosphoric acid is thrown down as double phosphate of uranium and ammonia, having a light brown color and a composition represented by the formula. $2(\text{Ur}_2\text{O}_3)\text{NH}_4\text{O, PO}_5 + \text{Aq.}$ This volumetric method for the estimation of phosphoric acid was devised by Francis Sutton, of Norwich, independently of Neubauer and

Pincus, who, independently of each other, also arrived at the same process; but Mr. Sutton states that Neubauer was the earliest discoverer of the method. The standard test-solution required is the nitrate of uranium, of which 1 c.c. represents 0.1 grain of phosphoric acid. A solution of ferrocyanide of potassium (yellow prussiate of potash), in the proportion of 1 to 20 is to be used as an indicator to stop the process so soon as the reaction is complete.

The details of the process are as follows:

(1) Take the precipitate produced by the baryta solution in 40 c.c. of urine: (2) wash the precipitate once with cold water; (3) treat it while still on the filter with warm acetic acid to dissolve all the phosphate of baryta which passes through the filter, leaving the sulphate behind; (4) wash the filter with a small quantity of boiling water, so as to remove the last traces of phosphate; (5) add sufficient ammonia to the solution to neutralize the acetic acid, unless the quantity of the latter be large, when somewhat less than enough to neutralize may be added. Under any circumstances the liquid must be fully acidified with acetic acid before being tested as to its strength (triturated), and must contain a tolerable quantity of acetate of ammonia; (6) take a measured quantity of the urinary phosphate solution (say 20 c.c.) in a beaker and gently warm it, and bring it under the burette containing the uranium solution; (7) portions of the uranium solution are to be delivered in and constantly stirred, until, when a drop is taken out with a thin glass rod and placed in the middle of a large drop of the solution of the yellow prussiate of potash on a white plate, a faint but distinct chocolate-brown color is produced at the point of contact. A slight excess of uranium solution is required to produce the brown color, which indicates that all the phosphoric acid contained in the amount of urine in the beaker has been thrown down; (8) record the amount of uranium solution used and estimate accordingly—1 c.c. of the solution precipitating 0.1 grain of phosphoric acid.

[Collect all the precipitates in a large bottle, and when suffi-

cient has been obtained, recover the uranium by igniting the dry precipitate in a porcelain crucible with the carbonaceous residue produced by burning tartrate of soda and potash in a covered crucible. The uranium is thus reduced to protoxide, while the phosphoric acid unites with potash and soda, and can be entirely extracted with boiling water. The protoxide of uranium left may be dissolved in nitric acid and evaporated to dryness in a water-bath.—Sutton's *Volumetric Analysis*, p. 208.]

The mean amount of phosphoric acid excreted in twenty-four hours is 3.164 grammes = 48.80 grains, with a range in the same person of from 35 to 50 per cent.—[See also table, p. 21 of this volume.]

The Therapeutical Indications will vary with the nature of the case; it must be the aim of the physician to guard against the deposition of the earthy phosphates within the urinary passages; in the cases where there is only an apparent, not a real increase of the phosphates, the alkaline reäction of the urine is most probably the cause of their precipitation; this is to be further investigated, and the cause of the alkaline reäction rectified. The cases of "phosphatic diathesis" require a tonic treatment; the preparations of iron, zinc or strychnine, together with rest, change of scene, and above all a generous diet, are most beneficial. Anodynes too have an excellent effect in restoring the acid character of the urine by their quieting influence on the nervous system.

The mineral acids are indicated in all cases except where the alkalinity of the urine and the consequent deposit of the phosphates is due to fermentive action in the bladder, the result perhaps of chronic vesical catarrh. In these the alkaline bicarbonates will prove useful.

In the foregoing part of this volume we considered abnormal urine, its odor, specific gravity, reäction, urea, creatine and creatinine, uric acid, the urates and phosphates. We shall continue the subject and commence with the consideration of

THE CHLORIDES.

We know that the presence of the chlorides in the blood and

urine depends upon their introduction into the system in the food; that they enter partly into the formation of tissue, and that all superfluity is removed by the kidneys and other emunctories of the body. Whenever we find, therefore, an excess of the chlorides, particularly of the chloride of sodium, in urine, and the amount introduced is inadequate to account for it, it is in all probability derived from, and represents change of tissue. In intermittent fever, there is an excess of chlorides in the urine, during the cold and hot stage. Some pathologists believe this to be due to an increased blood pressure in the Malpighian bodies during the cold stage. Vogel states, that in diabetes insipidus, the chlorides are in many cases considerably increased; the same is also true in dropsical affections, as it often accumulates for a considerable time along with an effusion in the tissue, and is freely eliminated whenever the kidneys perform their function with unwonted activity. It is clear that during the time of its accumulation in the transudation, it must be notably diminished in the urine. An increase after diminution is always regarded as a favorable sign. In the acute inflammatory affections, as pericarditis, pleurisy and pneumonia, its elimination is greatly lessened; and in bronchitis, phthisis pulmonalis, acute rheumatism, acute and chronic Bright's disease, cholera, typhus and typhoid fever, scarlatina, erysipelas, and puerperal fever.

In pneumonia, during the state of hepatization, it is entirely absent, and reappears during resolution.

It is stated by good authority that it is either accumulated in the inflamed portion of the lung, or the kidneys have temporarily lost the power of excreting the chlorides.

I am inclined to believe that the diminution of the chlorides in most of the affections enumerated above, is in a great measure dependent upon a less amount introduced into the system, and as physiology has taught me that chloride of sodium is not only discharged from the system in urine, but also in mucus, cutaneous perspiration, and other secretions, I explain its diminution or absence in the urine by the fact that the skin

and mucous membrane perform their functions quite actively during disease, stimulated as they are by the administration of medicine, and may thus rid the system of the small amount of chlorides introduced.

Dr. Beale has shown that there is a large amount of chloride of sodium contained in the sputa of pneumonic patients, and argues from this fact, that in pneumonia, chloride of sodium is determined to the inflamed lung.

I am aware that chloride of sodium does accumulate, to a certain extent, in the inflamed lung, and the amount must depend upon the extent and amount of exudation, and that, therefore, no more chloride of sodium will be found in the diseased lung than would naturally find its way in the exudation of *any* inflamed part of the body. The presence of chloride of sodium in the sputa of pneumonic patients, as proven by Dr. Beale, would rather sustain my argument, that the chloride is not *all* retained in the system, but only so much of it as goes in solution with the exudation to the inflamed part, and that the rest is eliminated in the mucus discharges, etc., since the sputa, of which he speaks, can not have reference to the expectoration of the exudation, which rarely, if ever, occurs in pneumonic patients, but simply to the sputa, consisting of mucus, etc., the result of hyperæmia of the mucous membrane lining the bronchial tubes, and the consequent hyper-secretion of mucus. The diminution of the chloride of sodium in the urine, during bronchitis, can also be explained in this way. It has been found in the discharges of cholera patients, while absent in the urine; and, in fact, in all transudations and exudations. Now, all of this would go to prove that chloride of sodium [in spite of not being eliminated by the kidneys in these affections] is not altogether retained in the system.

Practically, it matters little to know the cause of absence, increase, and diminution of this salt; the diagnostic value remains the same.

Chloride of sodium is easily *detected*; the urine is to be

acidulated with nitric acid, and a solution of nitrate of silver added; a dense white precipitate of chloride of silver quickly takes place; the amount of the chloride is estimated by comparison with healthy urine.

The average amount of chlorine excreted in twenty-four hours in health is about 8.21 grammes, or 126.76 grains; 13.6 grammes, or 210 grains of chloride of sodium were the chloride always united with that substance, an amount which Dr. Parkes thinks too great. Vogel and Parkes consider the mean to be 7 grammes, or 108 grains = 11.5 grammes, or 177 grains of chloride of sodium in twenty-four hours; the range above and below the mean being from 30 to 60 per cent. The weight of the body is to be considered.

Estimation of Chlorides.—They are calculated as "chloride of sodium"; the test solutions required are, the "standard solution of the nitrate of mercury" and the baryta solution. The method was devised by Liebig, and its principle is as follows: If the solution of the nitrate of mercury, free from any excess of acid, is added to a solution of urea, a "white gelatinous precipitate" is produced, containing urea and oxide of mercury in the proportion of one equivalent of the former to four equivalents of the latter. But when "chloride of sodium" is present in the solution, "the precipitate does not occur until all the chloride of sodium is converted into chloride of mercury (sublimate) and nitrate of soda," the solution "remaining clear." If the exact point be overstepped, the excess of mercury immediately produces the precipitate above described, so that the urea present acts as an indicator of the end of the process. It is, therefore, easy to ascertain the proportion of chlorides in any given sample of urine by this method, if the strength of the mercurial solution is known; since 1 equivalent of oxide of mercury converts 1 equivalent of chloride of sodium into 1 equivalent each of corrosive sublimate and nitrate of soda.—[Sutton.]

The steps of the process are as follows: (1) Take 40 c.c. of urine; (2) mix with 20 c.c. of the baryta solution; (3) pour

the thick mixture upon a small dry filter; and when sufficient clear liquid has passed through, (4) take 15 c.c. of it ($= 10$ c.c. of urine) and just neutralize it, or render it acid by a drop or two of nitric acid; (5) bring this urine fluid under the burette which contains the test solution of the nitrate of mercury, which is to be allowed to drop gradually, drop by drop, into the beaker containing the urine, which is to be constantly stirred with a glass rod; (6) as soon as the precipitate does not disappear by stirring, the operation is finished, but a permanent precipitate is produced ($=$ urea and oxide of mercury); (7) the volume of the test solution used is to be read off the burette, and the amount of "*chloride of sodium*" calculated therefrom; (8) the chlorine may be estimated by the following formula: As 58.8 equivalents of chloride of sodium contain 35.5 equivalents of chlorine, the chlorine in the urine is obtained by the equation—

58.8 : 35.5 :: amount of chloride of sodium in urine : X (the chlorine it contains).

THE SULPHATES.

The sulphates of potassa and soda are found in large quantities in the urine, and are held in solution like the alkaline phosphates; they are derived in part from the food, and partly from the oxidation of the sulphur, which enters into the composition of the albuminous substances of the body, and the subsequent union with a base of the sulphuric acid which is formed.

In health their elimination is increased, during the administration of potassa, sulphur, sulphuric acid, or the sulphates, a strictly animal diet and violent exercise have the same effect.

In disease, their elimination seems to go hand in hand with urea; an excess is particularly noticeable in febricula, typhoid fever, typhus, variola, pyæmia, milk fever, acute pneumonia, and, according to Bence Jones,* in delirium tremens, in chorea, and in functional and organic affections of the nervous system.

* Neubauer, Vogel, Sixth Edition; Weisbaden, p. 359.

Dr. Parkes found in rheumatic fever the sulphuric acid in the urine greatly augmented, but the urea not correspondingly so.

In order to *precipitate* the sulphates, add a few drops of nitric acid to urine, and subsequently from fifteen to twenty drops of a saturated solution of chloride of barium, a white precipitate, insoluble in acids, is thrown down.

The mean of sulphuric acid excreted in twenty-four hours is 2.012 grammes, = 31.11 grains, with a range of 45 per cent. above or below. The weight of the body is also to be taken into consideration.

Vogel gives an easy method of determining approximately whether it is increased or diminished. "After ascertaining the whole amount of urine in twenty-four hours—say it is 2000 c.c., and then each 100 c.c. would contain 0.10 grammes of sulphuric acid—100 c. c. are rendered acid, and as much of a test solution of chloride of barium is added as corresponds with 0.05 grains of the acid. [The test solution is made by dissolving 30.5 grammes of crystallized chloride of barium, powdered and air-dried, and diluting the solution up to one litre, 1 c.c. of it then equals 10 milligrammes of anhydrous sulphuric acid.] The mixture is now filtered, and if the filtered liquid is not made turbid by the chloride of barium, we may infer that the patient has secreted less than one gramme of sulphuric acid in the twenty-four hours. If the liquid, however, is rendered turbid by chloride of barium, then a further quantity of this agent, corresponding with 0.5 grammes of sulphuric acid, is added; and if the filtrate is still rendered turbid, it is evident that the quantity of sulphuric acid is greater than normal."

OXALATE OF LIME.

I have already pointed out the formation of crystals of oxalate of lime, in speaking of the changes during the decomposition of urine; and it has been stated that the appearance of these crystals in urine, after a day or two of its exposure to the atmosphere, was not at all a dangerous or morbid symptom.

This fermentation may be going on in the urinary passages,

and give rise to a sediment of oxalate of lime, soon after urine is voided. Dr. Owen Rees states that the oxalic acid in these cases is derived from the decomposition of uric acid and the urates, and this could only take place after the urine had been secreted by the kidneys.

Schunk, in a recent valuable contribution to the chemistry of the subject, established the presence in the urine of oxaluric acid, which he thinks presents an easy and satisfactory solution of the formation of oxalate of lime. The conversion of oxaluric acid into oxalic acid may take place after the urine is voided, or commence in the bladder, or even in the more remote parts of the urinary apparatus, and thus lead to the formation of calculi of oxalate of lime. The oxaluric acid is derived from the oxidation of uric acid.

There are two conditions which may lead to the production and discharge of the "oxalate of lime"; both, if long continued, are inconsistent with the welfare and safety of the individual. The first is the production of oxalic acid in the system, induced by the excessive use of certain articles containing it, particularly when digestion is deranged; the use of frothy, sparkling beer or wine, sugar in excess, turnips, parsnips, carrots, cauliflower, asparagus, sorrel, rhubarb plant, may all cause a "temporary oxaluria." The prognosis in this condition is, of course, much more favorable than in the one next to be described; but if the cause is sufficiently long continued, the deposition of oxalate of lime in the urinary passages may be effected, and a serious condition thus induced.

The second condition is, where patients discharge for weeks and months habitually a large amount of crystals of oxalate of lime, and when oxalic acid is known to have its origin in the system, attributable, perhaps, as Golding Bird believes, to a secondary or destructive assimilation of tissue; or, according to others, to impediment in the respiratory functions.

This condition has been termed "*Oxaluria*" or "*oxalic diathesis*," chiefly affecting persons (according to Prout, Begbie, Frick and others, who have observed and described cases) of a san-

guine or melancholy temperament; men belonging to the better classes, not used to making energetic efforts, indulging freely in the luxuries of the table, particularly in sweat-meats; suffering from indigestion, worn down by care and anxiety, their nervous systems shattered; generally those who have ruined their health and happiness either by excessive study, sexual indulgence, or masturbation. They constantly fear that a serious disease will overtake them, they become emaciated, their complexion assumes a dirty, dark hue, and they are either languid, irritable, dejected or desponding. Sometimes they are troubled with frequent seminal emissions and irritation of the bladder, with a loss of memory and a sensation of weight or dull pain across the loins, with a liability to boils and carbuncles, psoriasis and other skin diseases; in fact, these cases exhibit a train of symptoms which characterize low vitality and broken-down constitutions; their urine is of a high specific gravity, with an excess of urea, and ordinarily a deposit of mucus and crystals of oxalate of lime are seen.

The existence of "oxaluria" as a separate affection has been denied by many, among others, by Lehmann, Gallois, Smoler; but cases of the above described character are of such frequent occurrence that almost any physician has the opportunity to verify the truth of the symptoms, together with a large amount of oxalate of lime in the urine; he should never neglect in such cases to make a thorough search for the probable cause, and resort to efficacious remedies in order to prevent the formation of a most troublesome calculus.

The cases in which the formation of crystals of oxalate of lime is due to fermentive changes in the urinary passages, are not characterized by the constitutional symptoms above described.

The oxalates are often mixed with deposits of urates or uric acid; the earthy phosphates coexist sometimes (Beneke says always) in large amount with the oxalates. In the cases in which oxalic acid has its origin in the blood, the passage of crystalline oxalate of lime gives rise frequently to irritation,

and tube casts are the result. Dr. Da Costa mentions a case, which came under his observation, in which the patient suffering from a protracted and severe attack of "oxaluria" voided for weeks, along with the oxalates, casts of the character known as hyaline, exudative, or small waxy casts. Neither heat nor nitric acid detected albumen. Under treatment, the crystals disappeared from the urine, and with them the casts; the patient recovered perfectly, is reported as enjoying excellent health, and that he has not to this day had the slightest sign of degeneration of the kidneys.

In this connection I may mention that Dr. Walsh, of this city, in a lecture on gonorrhœa, stated that cases were most troublesome and obstinate to treatment when the patient indulged in the eating of asparagus, and that practical experience had induced him to interdict the use of this vegetable while treating a case of gonorrhœa. He stated that such was the experience of many physicians, who had taken the trouble to inquire into the diet of their patients, but could assign no particular cause. I conjectured at once that it must be the production of oxalic acid from the asparagus in the system, and that the passage of crystalline oxalates caused constant irritation and thus protracted the cure; subsequent experiments and investigations confirmed my conjecture. In the cases experimented upon, the eating of asparagus, rhubarb plant and other articles containing oxalic acid, invariably produced a greater or less amount of oxalates in the urine, and an aggravation in the local symptoms. The matter, though small in itself, is perhaps of sufficient importance to be remembered in the treatment of gonorrhœa.

The microscope is the readiest means of detecting the crystals of oxalate of lime; they appear in four forms: (1) In well defined octahedra of most varying size; and double quadrangular pyramids, united base to base. (2) As hour-glass contracted or dumb-bell-like bodies; these forms are not frequent, however. (3) Compound octahedra may be seen. (4) Long or pointed octahedra, or prismatic crystals, or flattened, bright

discs, *very readily mistaken for blood discs*, may be observed.

The Therapeutical Indication will vary with the cause; if it can be traced to fermentive action in the urinary apparatus, the cause is to be rectified by appropriate treatment: Mineral acids, tonics, change of habits, regulation of diet, abstinence from all saccharine food, rhubarb plant, asparagus (and all the above-mentioned articles), are indicated in most cases of "oxularia." Water containing lime should be avoided; and all constitutional symptoms treated upon general principles.

BILE IN URINE.

The presence of bile, or at least its coloring pigment in the urine, gives it a color varying from a saffron-yellow to a deep brown, and may lead to an unfounded suspicion of the presence of blood; the following tests will decide the question:

1. Pour on a white plate or sheet of writing paper a small quantity of urine, so as to form an exceedingly fine layer, carefully allow a drop or two of nitric acid to fall upon it, an immediate play of colors, commencing with green and blue, passing to violet or red, and often to a yellow or brown, will, if the coloring matter of bile is present and has not already been decomposed, appear around the spot where the acid falls. In the cases where the bile pigment has already passed through stages of transformation, the urine is generally of a brown or brownish-red color, and becomes red on the addition of nitric acid; sometimes, too, it is of a deep red, which nitric acid converts into a dark bluish red. Both Frerick's and Murchison have observed this condition; the former in undoubted cases of jaundice; the latter observer, in cases where there were no symptoms of jaundice, or where jaundice was due to a blood poison; but he frequently observed it in cases of functional derangement, or alteration in the structure of the liver.

The nitric acid test for bile pigment, as given above, may deceive the observer, inasmuch as an excess of indican may give rise to a very similar play of colors. The green color,

however, is characteristic of bile pigment alone; to avoid any possible error on the subject, a portion of the urine may be subjected to the test for uroxanthin (indican). If the mixture becomes black and opaque, depositing a deep blue or purple precipitate on being diluted with water, the play of colors may be attributed to the excess of indican.

A very *delicate test* for the bile pigment, as proposed by Dr. Basham, is to add a small quantity of chloroform to a portion of urine, the mixture is to be shaken; the chloroform will dissolve out all bile-coloring matter and retain it in solution. If this solution be then decanted and evaporated carefully, the pigment, which is left, gives, on the addition of a drop of nitric acid, a beautiful ruby-red color, after displaying the characteristic colors. This test is equally available for detecting bile pigment in other fluids.

The following is a ready mode by which the biliary acids may be detected: To a couple of drachms of the suspected urine add a small fragment of loaf sugar, and afterwards pour slowly into the test tube about a drachm of strong sulphuric acid. This should be done so as not to mix the two fluids. If biliary acids be present, there will be observed at the line of contact of the acid and urine—after standing for a few minutes—a deep purple hue. This result may be taken as a sure indication that the jaundice is due to obstructed bile-ducts. On the other hand, the absence of this phenomenon, and the occurrence of merely a brown instead of a purple tint, although in the earliest stages of jaundice, equally indicative of suppression, is no indication of the cause of suppression, which must be gleaned from other circumstances.—(Harley, "On Jaundice," p. 61.)

Dr. Flex Hopper's method is as follows: (1) Decompose the icteric urine to be examined with an excess of milk of lime; (2) boil for about half an hour; (3) filter; (4) evaporate the filtered fluid nearly to dryness; (5) decompose with a great excess of concentrated hydrochloric acid, then keep the whole (before being again filtered) at the boiling point for half an

hour; (6) to avoid spouting of the fluid, it is necessary to renew the volatilized hydrochloric acid from time to time; (7) leave the liquid to get completely cold, and then add six to eight times its volume of water; (8) filter the brown turbid solution thus obtained, wash out with water the residue on the filter until the same runs through quite colorless; (9) dissolve the brown resinous mass on the filter in 90 per cent. alcohol; (10) decolorize by boiling with animal charcoal, filter and evaporate to dryness in the water-bath; the residue is a yellow, resinous mass, which, if bile acids be present, must consist, for the most part, of pure "choloidic acid." In such a case it melts by warming, and emits the peculiar musk or soap odor; (11) lastly, dissolve in a very little caustic soda and some drops of warm water, add a very small piece of sugar, and allow three drops of concentrated sulphuric acid slowly to fall into it. At first the fluid becomes milky and troubled, and resinous flakes separate, which stick pertinaciously to the glass; but afterwards, by the addition of more sulphuric acid, these again dissolve and produce a beautiful purple, red, or dark-violet fluid.—[Abstract of Kühne's paper on the pathology of "Icterus," by Dr. George Scott, of Southampton, in "Beale's Archives," vol. 1, p. 343.]

Pettenkoffer's test for biliary acids is familiar to all, and consists in tincturing with a few drops of solution of sugar (one part to four of water) a small quantity of urine in a test tube or china dish, add to this mixture, drop by drop, sulphuric acid; at first a whitish precipitate is occasionally seen, but redissolves in a slight excess of sulphuric acid; the acid should be added until the mixture assumes a somewhat syrupy consistency and an opalescent look, owing to the development of minute bubbles of air. A red color then begins to show itself at the bottom of the test tube, and afterwards spreads through the mixture, until the whole fluid is of a clear, bright cherry-red. This color gradually changes to a lake, and finally to a deep, rich, opaque purple. If albumen is known to exist in the urine, it is to be coagulated and removed by filtration.

Various objections have been urged against this test. Robin

and Verdeil say that its reactions do not belong exclusively to the bile, and may, therefore, give rise to errors. Oleic acid, oil of turpentine, oil of caraway, are stated to have produced a similar play of color. The objections have no practical weight, inasmuch as the presence of bile with any of the named substances must be a very rare coincidence indeed; and since we are always aided by the general symptoms.

The presence of bile in the urine is often apparent to the eye, and is apt to stain the patient's linen; it is of rare occurrence in health, though Scherer has noticed traces of the coloring matter during the hot season. The presence of this substance is only of importance in diagnosis, when the general symptoms of jaundice are marked. Its presence indicates that the kidneys are called upon to perform the work of a deranged liver, or to rid the blood of an excrementitious substance, which, owing to an impediment in the biliary passages, have been reabsorbed.

The biliary acids have been found in the urine in jaundice and acute atrophy of the liver. Their presence indicates accumulation in the blood, which may either be due to their improper destruction or transformation therein, or to an hyper-production in the liver. "The causes which prevent their transformation in the blood are, as yet, obscure; but their presence exercises a powerfully depressing influence over the nervous system, particularly the cardiac nerves."—(Gerhardt.)

That the presence of the biliary acids in the urine is in great measure due to non-destruction in the blood, is seen from the fact, that in jaundice we do not always find the biliary acids with the bile pigments, or if so, in an inadequate amount, simply because the acids are gotten rid of, as Vogel believes, in the usual way in the blood. Therapeutical Indications: *Treat the cause.*

SUGAR IN URINE.

Sugar is occasionally found in the urine of persons in health, and can either be accounted for as a product of decomposition of the indican, or by an undue introduction of saccharine or

farinaceous articles into the system. It has also been detected in the urine during or after the administration of ether, chloroform, or hydrate of chloral; it would seem that in these cases it was owing to a loss of power of the lungs (during anaesthesia) to destroy sugar, and its consequent accumulation in the blood. According to the observations of Bordier, sugar is frequently found during convalescence from acute affections, as pneumonia, phthisis, rubeola, erysipelas, and other inflammatory fevers; but unless the quantity is small and transient, or a proper account for its presence can be given, it constitutes diabetes mellitus. Before entering into the causes of diabetes, it must be stated that sugar has frequently been found in considerable quantity in the urine after injuries of the brain, disturbances of the nervous system, particularly the medulla oblongata. The prognosis in the first instance, as far as the glycosuria is concerned, is favorable.

The causes of diabetes mellitus are generally believed to be due—

1st. To an undue introduction of sugar into the blood, whether from hyper-production of sugar in the liver, in the alimentary canal, or in both.

2d. To a deficient destruction of the sugar, the quantity not being increased.

3d. To an increased introduction and deficient destruction combined.—[Flint.]

The urine in this affection is voided in abnormal quantities, the color is light, its odor is a peculiar sweetish one, and its specific gravity varies from 1030 to 1074.

The amount of sugar excreted differs in different cases. Dr. Austin Flint, Jr., mentions a case in which the quantity of urine passed in twenty-four hours was 89 ounces, specific gravity 1037. The amount of sugar in one ounce was 36.363 grs.; in the whole quantity, 6 ounces, 356.16 grs.

Several tests have been proposed to detect the presence of sugar.

The following is Trommer's test, familiar to all, and if used

with the necessary precautions, is sufficiently delicate and reliable. It depends upon the fact that the saccharine substances have the power of reducing the persalts of copper when heated with them in an alkaline solution: "Add a very small quantity of sulphate of copper in solution to the suspected urine in a test tube, render the mixture alkaline by the addition of caustic potassa; the whole solution then takes a deep blue color. On boiling the mixture, if sugar be present, the insoluble sub-oxide of copper is thrown down as an opaque, red, yellow, or orange-colored deposit; otherwise, no change of color takes place."

I have pointed out that the presence of some organic ingredient will interfere with the above test. To insure reliability, the urine is first to be treated with an excess of animal charcoal and filtered. If albumen is present, it should be coagulated and treated in a similar manner. Chloroform, creatine, and uric acid are stated to have the power of reducing the salts of copper; and Beale has shown that the presence of the ammoniacal salts will prevent the precipitation of the sub-oxide of copper in specimens of urine containing but little sugar.

Moore's test is the simplest, but not the most reliable. It consists in boiling the suspected urine with an equal quantity of liquor potassa. If the mixture contains sugar, it becomes brown, which grows deeper the longer the boiling is continued. This test is not applicable when the urine contains traces only of sugar.

Fermentation Test.—A common test tube is to be filled with the suspected urine, a little ordinary yeast is to be added, and then inverted and placed in a saucer containing urine, care being taken to prevent the entrance of air; kept at a temperature of 70° Fahr., fermentation ensues, and the gas formed rises in the tube and displaces the urine. The gas is shown to be carbonic acid, from its failure to support combustion. According to Dr. Christison, one cubic inch of carbonic acid indicates one grain of sugar.

Another fermentation test, known as "the differential den-

sity method," has been proposed by Dr. Roberts, and recommended by Professor Doremus. It is based upon the fact that the sugar, if any is present, undergoes, as in the preceding test, alcoholic fermentation; and that, by this process the density of the urine is diminished; each degree of density lost represents one grain of sugar to every fluid ounce of the diabetic urine.

The details of the process are as follows: Put four ounces of urine, mixed with a lump of German yeast about the size of a chestnut (or if this is not at hand, use ordinary brewer's yeast), into a twelve-ounce bottle, close it with a nicked cork, for the purpose of allowing carbonic acid to escape, and set it near a warm place for fermentation. A four-ounce vial, containing a specimen of the same urine without the yeast, is to be closely corked and placed alongside the other bottle, for the purpose of avoiding any error, which might occur, if the specific gravity of the urine both before and after fermentation was obtained at different temperatures. After twenty-four hours the fermentation will have ceased. Both bottles should be taken to a cool place, so that the urine may acquire the temperature of the surrounding air. The specific gravity of the two specimens of urine is now taken, and their difference in density, as determined by the urinometer, indicates the number of grains contained in each fluid ounce of the saccharine urine.

"Fehling's test" is very reliable for the detection of sugar. The following test is similar to Fehling's, and is based on the fact, that although a mixture of pure sulphate of copper, tartrate of potash, and caustic soda, mixed in proper proportions, may be boiled without undergoing change; yet, if only a trace of sugar be added, a very slight warming is enough to precipitate a portion of the copper as a protoxide $[Cu_2 O.]$ It is found that one atom of pure sugar, equal 180, is capable of reducing exactly ten atoms, equal 307 of oxide of copper $[Cu O]$ to the state of protoxide. Therefore, if the quantity of copper reduced by a given solution of sugar is known, it is easy to find the quantity of sugar present (Sutton). A standard solution of pure sulphate of copper with tartrate of potash and caustic

soda is required. It is to be prepared as follows: (1) 346.4 grains of pure sulphate of copper, previously powdered and pressed between blotting paper, are weighed and dissolved in 200 c.c. of distilled water; (2) In another vessel 1,730 grains of pure crystallized tartrate of soda and potash (Rochelle salt) are dissolved in 480 c.c. of solution of pure caustic soda (specific gravity 1.14); (3) The two solutions are then to be mixed, and the deep, clear blue solution diluted with distilled water till the whole measures 1,000 c.c. One c.c. of the solution so prepared represents 0.05 grains of grape or diabetic sugar. It must be preserved for use in a dark place, and in well-stoppered bottles kept full. It should bear heating when diluted with about four or five times its quantity of distilled water, without any precipitate taking place; and should always be submitted to this test before being used. If any precipitate does occur, it probably arises from the alkali having absorbed carbonic acid; and in this case the addition of a little fresh caustic soda solution remedies the evil.—[Sutton.]

The following are the details of the process for analysis: (1) 10 c.c. of clear urine are diluted by means of a measuring flask to 200 c.c. with water, and a large burette filled with the fluid; (2) 10 c.c. of the copper solution (equal to half a grain of sugar) are then measured into a flask, or white porcelain capsule, and 40 c.c. of distilled water added; (3) The vessel is to be arranged over a spirit-lamp under the burette, and brought to boiling; (4) The diluted urine is then delivered in, cautiously, from the burette until the last traces of blue color are removed from the copper solution, and the precipitate is of a distinct red color; (5) It must be remembered that the urine has been diluted twenty times, so that the quantity used, divided by twenty, will represent the amount of the original urine used, and the estimate is to be made accordingly.

Other tests have been proposed, but any of the above will answer all practical purposes. The presence of the "torulæ cervisiae" seen under the microscope confirms the presence of sugar in the urine. The torulæ form two or three hours after

emission a gelatinous mass, composed of sporules, which subsequently develop into beaded threads, and in a few days aerial fructification appears.

For therapeutical indications, I must refer the reader to treatises on "Diabetes Mellitus." If the cause and source of the mischief was better understood, the therapeutical indications could be more satisfactorily determined.

Inosite.—This is a substance which belongs to the group of sugars, and has recently been discovered in morbid urine, accompanied either by grape sugar or albumen. Its origin and significance are as yet obscure. Vogel deems it not unlikely that it is derived from the glycogen in the liver, since irritation of the fourth ventricle in animals produced "inosuria" instead of "glycosuria." Cloetta found inosite in the muscles, lungs, kidneys, spleen and liver, and detected it with ease in the urine in Bright's disease. Vohl found it in diabetic urine, in which it gradually filled the place of sugar. Gallois has described cases of inosuria (De l'Inosurie, Paris, 1864). It is a symptom rather than a disease. The characteristic reäction of inosite is exhibited when a solution of the substance is evaporated nearly to dryness. The residue is to be moistened with ammonia and a little calcium chloride solution, after which it is again evaporated, when a rosy red substance will be left. Inosite has not the power of reducing the copper salt, when Trommer's test is applied.

Extractive Matters are found in urine during certain morbid conditions of the system, and are derived from the blood. The tincture of galls, as recommended by Dr. Owen Rees, precipitates them immediately, while healthy urine is not affected; the precipitate, however, is not to be confounded with that of the earthy or potassa salts, which are thrown down in any kind of urine, after five or ten minutes, by the alcohol contained in the tincture. If albumen is present, it is to be coägulated by boiling and separated by filtration before applying the test.

The presence of the blood extractives in the urine indicates hyperæmia or inflammation in some part of the urinary pas-

sages, and the consequent transudation of blood material. Dr. Owen Rees, in a recent contribution to medical literature, has pointed out that in Bright's disease the extractives can be found in the urine before the presence of albumen is detected, and after albumen has disappeared. Dr. Rees deserves great credit for these observations; as they are of great importance in diagnosis and prognosis, since we can infer on the one hand an approach of albuminuria, and on the other hand that the patient is not yet out of danger. Dr. DaCosta, from whose work on diagnosis this information is obtained, states that the presence of the extractives will enable us to diagnosticate nephritic irritation from renal calculus, before albumen, blood or pus have appeared, and deems it highly probable that the extractives will be found preceding albumen in urine in most cases.

ALBUMEN IN URINE.

Albumen is occasionally detected in the urine of persons in health, but unless the quantity is small and can be accounted for by an exclusive albuminous diet, is a condition which requires a thorough inquiry on the part of the physician into the probable cause.

The causes for albumen in urine may be arranged under the following heads :

(1) *Albuminuria*, depending upon a congested state of the kidneys, which is so generally the case at the onset of all acute inflammations of important viscera in the body. Thus it has been observed in pneumonia, pleurisy, pericarditis, hepatitis, peritonitis, metritis, and phrenitis ; also in different other affections, as typhoid and typhus, in all the eruptive fevers, in diphtheria, rheumatism, gout, after surgical operations, etc.

(2) *Albuminuria*, depending upon congestion of the kidneys, of spontaneous origin, and the actual destruction of the secreting cells [in all inflammatory affections of the kidneys, Bright's disease, also in encephaloid and other malignant diseases of the kidneys.]

(3) *Albuminuria*, depending upon impeded circulation, as

in valvular disease of the heart and portal congestion, also upon passive congestion produced by the pressure of an abdominal tumor, or impregnated uterus upon the renal veins.

(4) *Albumen* in urine may also be the result of an admixture of blood or pus; and finally it has been observed during anæsthesia, during the internal and external use of carbolic acid and turpentine, after the application of a fly-blister, and after the inhalation of carbonous oxide (new).

It will be seen that albumen is found during many affections of the system; the amount and continuance of it, together with the history of the case, must guide us in our opinions; yet we should never omit to direct our attention to the kidneys, and with the aid of the microscope we may be enabled to diagnose the different affections of the urinary organs.

Tests for Albumen.—(1) Heat, which coagulates the albumen. (2) Nitric or carbolic acid, which cause a white precipitate. (3) Corrosive sublimate, which also causes a precipitate. The first and second test, used with the necessary precautions, are the most convenient. The application of heat may render the fluid thick by throwing down the phosphates instead of the suspected albumen; the question can easily be decided by adding a few drops of nitric acid; the turbidity, if owing to the phosphates, will at once disappear.

In alkaline urine, particularly if the quantity of albumen is small, heat will not produce coagulation. The urine should be rendered slightly acid by acetic acid or nitric acid, the former is preferable, since it does not precipitate albumen before heat is applied. A highly acid urine behaves like an alkaline urine.

The nitric acid test usually employed may deceive an inexperienced observer, for it may give rise to a precipitate which is not albumen; it may deposit the urates, or even uric acid; upon boiling urine, however, the mixture quickly clears if the opacity is not caused by coagulated albumen. There can be seldom any doubt when albumen is present in considerable quantity;

it is only when but traces are found that the test requires verification. To avoid all errors, the urine should be boiled, after having ascertained its reäction, in a clean test-tube over a spirit-lamp, and then the acid added. A second specimen should be tested by Heller's mode, which consists in holding a test-tube, about one-third full of urine, in an inclined position in the left hand; twenty drops of nitric acid should then be allowed to run gradually down the side of the tube, the acid collects at the bottom, and if albumen is present, an accurately defined layer will be seen collected above the acid.

The urates are, in the last test, also affected, but the layer of albumen is so well defined above the acid that an error is almost impossible; above the layer of albumen in the test-tube a clear layer of urine is observed, and above this, a layer of turbid urine, produced by the urates.

Care is to be taken not to add too much nitric acid to suspected albuminous urine, as the albumen may be re-dissolved; while, on the other hand, a drop or so only may retard, instead of favoring, coägulation. Dr. Andrew Clarke (in the London Hospital Reports, vol. i., p. 226) called attention to the fact, that both heat and nitric acid may not, for the time being, detect the presence of albumen; yet, after a few hours, a flocculent precipitate may form and fall to the bottom of the tube. A remarkable substance, allied to albumen, has been detected in the urine, by Dr. B. Jones, in a case of rickets. It differed from albumen in not being precipitated by heat or nitric acid. But on boiling the urine and allowing it to cool, a precipitate fell, which re-dissolved on the application of heat. The substance, which was precipitated by alcohol, was the hydrated deut-oxide of albumen. Scherer has also met a modified form of albumen, precipitable only by alcohol.

The following is the carbolic acid test solution, as recommended by Mélne: "Take of crystallized carbolic acid 1 part, by weight; commercial acetic acid, one part; alcohol, 90 per cent., two parts. This solution undergoes no change on keeping. It is used as follows: To 100 grammes of urine add 2 c.c. of com-

mercial nitric acid, and thoroughly mix. Upon the addition of 10 c.c. of the carbolic acid solution, the albumen is precipitated in white flakes. In testing highly albuminous urine or albuminous solutions charged with salts, the addition of nitric acid is scarcely necessary.".—(Dacosta.)

To determine the exact quantity of albumen present in the urine, a measured quantity of urine is to be acidulated with acetic acid, placed in a Florence flask, and to be heated in a water-bath until it boils. The coagulum which is formed should be collected on a filter, dried, and weighed. The easiest method, and one much practiced, is to acidulate a test tube full of urine with acetic acid; the mixture is subsequently boiled and allowed to settle. The proportion of the precipitate to the entire bulk is then expressed as one-half, one-fourth, or one-fifth, as the case may be.

FIBRIN IN URINE.

Fibrin either in a fluid or coagulable state has been found in the urine in certain morbid conditions of the system; it is present whenever blood is present, and the blood coagula can not be mistaken very well for anything else; occasionally it is either seen as a firm, colorless, or gelatinous mass, or as the exudative casts under the microscope. Fibrin in a fluid state is often encountered in the urine of persons living in Brazil (Isle de France), and is known as "coagulable urine"; the name is derived from the fact that the fibrin a few hours after emission coagulates, and forms either a sediment, or if present in larger quantities, gives the fluid the appearance of a gelatinous mass. Vogel states that this condition may often be mistaken for urine containing pus.

"Coagulable urine" may or may not contain blood, the size of the coagula is in some degree a guide, whether the fibrin is derived from the blood effused or not; Vogel mentions the case of a woman afflicted with Bright's disease, in which the urine for a number of days, a few hours after it was voided, exhibited pinkish coagula of fibrin at the bottom of the vessel; the coag-

ula contained numerous white blcod corpuscles, but only a few red corpuscles, so few indeed, that the blood which they represented could not have furnished the whole amount of fibrin present.

The presence of fibrin in the urine indicates the exudation of liquor sanguinis in some parts of the urinary system ; it is most generally derived from the kidneys, but may originate from any part of the urinary passages.—(Vogel, p. 2697.)

BLOOD IN THE URINE.

Urine of a peculiar red color, of a more or less smoky hue, depositing upon standing a dark coffee ground sediment, may naturally arouse suspicion that hæmorrhage in some part of the urinary passages is taking or has taken place. The physician should remember, that many other causes may change the color to the hue above described. To make sure then of the presence of blood, the urine should be heated, or nitric acid added ; if it becomes turbid and its color changed to brown, blood is present ; the discovery by the microscope of floating blood discs is the most conclusive proof.

The next step is to determine the source of the blood. If it is urethral or vaginal, it is easily known by the circumstances attending it, or upon digital examination ; it escapes generally without any effort of micturition.

If it comes from the bladder, there is a frequent desire to pass water ; the blood is not equally diffused in the urine when voided ; there may be retention of urine after one or two evacuations of bloody urine, produced by a coägulum in the mouth of the urethra.

When the blood is derived from the kidneys the microscope may reveal blood casts ; the epithelium enlarged in the blood, is small and more or less round, very unlike that from the bladder, which is larger, flat and scaly ; there is generally pain and evidence, perhaps, of either an organic lesion or the passage of a calculus ; blood clots under these circumstances are only formed in the ureters or infundibulum of the bladder, their passage gives rise to distressing pain, they are of a cylindrical

form, and owing to their intermixture with clear urine are of a white color.

Mr. John Hilton recommends, in order to study the clots more closely, to float them out in water; they frequently exhibit the shape of the cavity in which the blood was effused, the clots formed in the bladder, for instance, have irregular circular outlines, are flattened in shape, with serrated or beveled edges.

Now to consider briefly the causes of haemorrhage. As has been observed, it may be urethral or vaginal; in the latter instance, it may come from the uterus, or the wall of the vagina. Causes of a traumatic or idiopathic character may be productive of the haemorrhage, and to enter into these, is not within the scope of this treatise.

Vesical haemorrhage may be due to a calculus, erosions of the walls of the bladder produced by malignant growths, chronic inflammation or otherwise; it may be due to hyperæmia of the mucous coat and consequent rupture of blood vessels (as in the so-called vesical haemorrhoids). In diagnostinating the different causes, we are aided frequently by the presence of gravel, fragments of calculi, pus, cancer cells, and the characteristic symptoms of the affliction producing the haemorrhage. Haemorrhage from the uterus generally involves the presence of a calculus. If the haemorrhage is renal and the blood considerable, it is generally derived from the pelvis of the kidneys, induced by the passage of a calculus or the existence of cancer. Pyelitis is one of the most frequent causes of haemorrhage. If the blood is derived from the parenchyma of the kidneys, the quantity is small, and is generally indicative of the existence of Bright's disease; the tube casts, pus corpuscles and the presence of albumen, generally confirm the diagnosis of the source and cause of the mischief. The blood in these cases is derived from the vessels of the Malpighian bodies. Hyperæmia of these vessels may also be produced by the undue administration of stimulating diuretics, as turpentine or cantharides, and a bloody urine is often the result.

A form of intermittent haematuria has been described by Dr.

Edward H. Greenhow. The affection is characterized by a large amount of fibrin, with comparatively few red blood corpuscles. Crystals of oxalate of lime and hyaline casts have been observed in the urine during the paroxysm. The disease is ushered in by a chill, followed by an imperfect hot stage and more rarely by sweating. The short duration of the affection shows the absence of inflammation or any important lesion of the kidneys. Flint believes it to be a constitutional disease of which the haematuria is only a local expression. From its paroxysmal character it was supposed to be a variety of ague, but Dr. Greenhow says it is not. The aetiology is likely to remain obscure for some time. Greenhow's observation was limited to seven cases; and it has never been observed in this country. Another form of haematuria prevails in certain towns of the Cape of Good Hope, Mauritius, Egypt, and Brazil, which has been called "endemic haematuria." Dr. John Harley has found it to be caused by a parasite (*bilharzia haematobia*) belonging to the family *distomvesra*, (of the class "frematodia"), which inhabits the small vessels of the mucous membrane of the urinary passages and kidneys. The larvae of this parasite are found in the river-water of the above named places, and gain access into the system by drinking of the water during the act of bathing.

Blood-pigment or haematin dissolved in the urine does not always indicate local disease or rupture of a blood vessel in any part of the urinary passages; it must be regarded as indicating rather a specially morbid condition of the blood, as it is associated with septic poisons, or with the cachectic disease.—(Parkes.)

It may be observed in typhus fever, malignant variola, remittent fever, yellow fever, scurvy and purpura. Finally the physician is to remember that blood is often mixed by malingerers and others for the purposes of deception.

The therapeutical indications will vary with the nature of the case; care is to be taken to prevent the retention of a coagulum in the bladder, as it may form the nucleus of a calculus. Rest and astringents are important indications in all haemorrhages.

FAT IN URINE.

Fat occurring in the urine, unless we can account for it by an undue introduction of articles containing oil into the system, or that it has been mixed for the purpose of deception, is indicative of a grave pathological condition of the kidneys. I have, particularly, reference to fatty degeneration of that organ; the fat in these cases appears in the urine either in free globules, in cells, or in tube casts; the fat may also be due to fatty degeneration of the epithelial cells of the ureters and bladder.

In some cases fat is met with in the urine in a molecular state, giving the fluid a milky appearance, termed by Prout *chylous urine*. Dr. B. Jones believes this condition to be due to the chyle in the blood, which, on account of some alteration of the structure of the kidneys, exudes during active circulation, in connection with one or more constituents of the blood from the capillaries, and recommends the use of astringents. Dr. Beale, though admitting the intimate connection of this condition with the absorption of chyle, does not consider it to depend upon any permanent morbid change in the secreting structure of the kidney.*

The tests for fat are its solubility in ether, the microscope, and a very simple one, the paper test; this consists in dipping

* Dr. T. R. Lewis, Assistant Surgeon H. M. British forces, Calcutta, has written an excellent memoir on a *hæmatozoon* inhabiting human blood and its relation to chyluria. In March, 1870, the Doctor discovered, while examining some chylous urine, a *hæmatoid* worm in it; but carried his researches no further. It was not until July, 1872, that he was led to the belief that this worm (to which the name *Filaria Sanguinis Hominis* has been given) stood in causative relation to chylous urine; he examined such urine associated with more or less marked *hæmaturia* in between fifteen and twenty patients, and has found them in all cases in the excretion; in many if not in all the patients, he also detected them in the blood. The average diameter of this species of *filaria* is that of a red corpuscle, and its average length 46 times greater—i. e., it is 1-3500 of an inch one way, by 1-25 the other.

It is highly probable that the pathology of this mysterious affection has been unraveled by Dr. Lewis.—(Amer. Jour. Med. Sciences. Oct., '73, page 517.]

a piece of white paper into the fatty urine, and if, after drying, a greasy spot remains, the proof is conclusive.

Lea and Atlee have recently pointed out an error which is apt to occur in analysis of urine—viz., an illusory detection of fat. They found, in testing a specimen of urine, that the ether rose to the top so charged with matter as to resemble a half liquid pomade. Separated by a pipette and spontaneously evaporated, it left a dirty-whitish, greasy mass. A careful examination of this residue showed that instead of consisting of fatty acids, it contained nothing but the normal constituents of the urine, for it was soluble in water, reappearing as normal urine. It was then ascertained that almost any specimen of urine will form an emulsion when violently agitated with ether, especially if the ether contains a small amount of alcohol, but this condition is not essential. When, therefore, ether appears to dissolve out fatty matter from urine, the ethereal solution should be separated, allowed to evaporate spontaneously, and, if the residue be soluble in water, it can not be held to contain fat.

In some cases, the oil is detected by the unassisted eye, but errors are unavoidable in trusting merely to the appearance of the fluid. The opalescence caused by a sediment of urates, the pellicle which often forms on urine (consisting not of fat, but vibriones, fungi, and crystals "of triple phosphates"), as well as the "kyestein pellicle," observed in the pregnant state, have all been mistaken for that of fatty matter; some oily matter does enter into the composition of "kyestein."

A fatty matter was discovered by Keller in the urine of a patient, and termed by him "uro-stealith"; its pathological relation is unknown, since experience is limited to but one case.

In all cases the physician should satisfy himself that the fatty urine was really discharged by the patient, and not caused by a greasy urinal or the admixture of oily medicinal substances.

I shall now consider a few substances, not yet spoken of, which generally form sediments in the urine after secretion, and which may deposit in the renal passages or after emission.

The sediments of uric acid, urates, and phosphates have been discussed with the different constituents of urine.

Sediments of Hippuric Acid.—Owing to the solubility of this acid, its sediments are rare. When it does occur, it appears under the microscope in the shape of long, four-sided, acuminate prisms, or slender needles fixed in uric acid crystals, with which they are sometimes confounded, as well as with phosphates. They are distinguished from phosphates by being insoluble in acids, and from uric acid they may be separated by boiling with strong alcohol.—(Parkes.) The causes which produce the precipitation of hippuric acid are much the same as those effecting the deposit of uric acid.

Hippuric acid has been found in considerable quantity in the urine of persons in health, after the ingestion of certain fruits and berries, as the cloudberry (*rubus chamæorus*) and the myrtleberry (*vaccinium vitis idæa*). The introduction of benzoic and cinnamic acid has had a similar effect. In disease, the physician should first satisfy himself whether the hippuric acid has not been produced by the use of these articles.

It has been found in large quantity in the acid fever urine of patients. Lehmann attributes the acidity of this kind of urine to the presence of hippuric acid. It has also been found to be present in diabetes and chorea.

2. *Sediments of Leucine* are precipitated in round corpuscles, sometimes with a concentric form, and look like heaps of fat; but when crystallized from pure solutions, it appears as fine, dark-colored, needle-like crystals. To recognize it fully, it must be separated by careful sublimation.—(Parkes.) The suspected leucine is to be placed on platinum, carefully moistened, and then dried with nitric acid. The almost imperceptible flake which is left is to be moistened with caustic soda and evaporated carefully over a spirit-lamp. If leucine is present, it forms an oily-looking drop.—(Scherer.)

3. *Sediments of Tyrosine* are of a greenish-yellow color, composed of heaps of fine needles, which can be obtained on evaporation. It ought to be treated with nitric acid, like leucine,

and then a little liq. sodæ used. The nitric acid gives a deep orange-yellow color, which becomes deep yellow on evaporation. The soda gives the yellow flake a red tinge, and on heat and evaporation, a black-brown residue is left.—(Scherer.)

Hoffman has proposed the following delicate test: A solution of mercuric nitrate, nearly neutral, is to be treated with the solution suspected to contain tyrosine; if it is present, a reddish precipitate is produced, and the supernatant fluid is of a very dark rose color.

Both Leucine and Tyrosine are the result of disintegration of highly nitrogenous tissues, supposed to be especially derived from the principal glands. They have never been noticed in urine in health, and are generally associated in disease, as in acute yellow atrophy of the liver, in typhus fever and small-pox. A larger quantity is found in the urine in gangrene. Urea in these cases is notably diminished or entirely absent in the urine, being replaced by the leucine and tyrosine.

4. *Sediments of Cystine* form a white or light fawn-colored amorphous, rather bulky precipitate, or they appear at once as six-sided plates. In both cases ammonia dissolves it, so do fixed alkalies and their carbonates; and from this solution it crystallizes on spontaneous evaporation. It does not disappear when the urine is gently warmed, and it is insoluble in carbonate of ammonia, in dilute hydrochloric acid, and in acetic acid.

Its presence in the urine is of rare occurrence, and only important as it may give rise to the formation of a calculus in the renal passages. Scherer has found it in the liver, and since it contains much sulphur (over 25 per cent.), its elimination is generally associated with derangement of the functions or organic disease of that organ. It is not at all unlikely that it is produced there. It is a curious fact that cystine has been found in the urine, in many instances, in members of the same family.

5. *Sediments of Xanthine* have been observed in a crystalline form by Dr. Bence Jones (Journal of the Chemical Society, 1862). It has long since been known to form calculi in the

urinary passages, and a sediment is therefore always of importance to the physician. The cause of increased production of this substance in the system, and the formation of sediments, are, as yet, obscure. Pure xanthine can be obtained from urine containing it by the following mode of procedure:

Precipitate with baryta water, filter, evaporate to a syrup, and set aside to crystallize. Remove the crystals, dilute the mother liquid, and boil with cupric acetate. Wash the precipitate thereby produced, dissolve in warm nitric acid, reprecipitate with nitrate of silver, wash the precipitate, and crystallize it from dilute nitric acid. Wash the crystals with ammoniacal silver solution, decompose by sulphuretted hydrogen, filter, evaporate to a low bulk, and wash with a little water the deposit of "xanthine."

Hypoxanthine is closely allied to the above; it has been found in the pancreas, spleen, and liver of man, and in small quantity in the urine.—(Strecker.) It is evidently a product of animal tissue changes, and its chemical composition is similar to that of uric acid.

Allantoine is, as yet, of no importance to the physician; it appears in the urine of cows and calves, and has been observed in the urine of new-born infants. Schottin found it in urine of man, after the undue introduction of tannic acid into the system; and Frerichs and Stüdeler in the urine of dogs during impeded respiration. It can be artificially produced from uric acid, as follows:

Take 20 grammes of uric acid, stir up in 200 to 400 c.c. of water, add a small quantity of acetic acid, gradually introduce 100 grammes of lead peroxide, and expose to sunlight for some time. Boil, filter, and evaporate the filtrate until, on cooling, the allantoine crystallizes out in glassy, tasteless prisms.

I shall now consider urinary deposits, consisting chiefly of organic bodies, which are derived either from the structures of the urinary organs, or are the products of disease, as inflammation, cancer, and tubercle.

1. *Mucus and Epithelium* from the urinary passages. Mucus

is always present in urine; but in health the quantity is so small that it forms but a dim cloud. In the febrile affections, as pneumonia, pleuritis, typhus, etc., the quantity is increased, and in the catarrhal inflammation of the mucous membrane of the urinary passages the quantity increases to such an extent as to form a deposit soon after the urine is voided. This deposit consists of mucus and epithelium, and the particular character of the latter often enables us to trace the mischief to a certain locality of the urinary organs. The microscope, though readily discerning the epithelium, does not distinguish the mucus until it has been precipitated by alcohol and acids, or by the addition of diluted tincture of iodine.

The epithelial cells from the *bladder* are of various sizes and stages of formation, and frequently free nuclei are seen. In catarrh of the bladder, the mucus, from its cohesion, is apt to form transparent flakes or cylinders, resembling casts from the pelvis of the kidney.

The epithelium from the *ureter* is columnar in its character, and not unlike that found in the male urethra, which is mostly columnar, and is more flattened than that of the bladder, and less regular than that of the pelvis of the kidney. Mixed with it, there is a good deal of scaly epithelium, especially towards the orifice of the urethra.

The epithelial cells from the *pelvis of the kidney* are often triangular or caudate, with well-defined nuclei. They generally adhere together in groups of three to ten, when they appear to have an imbricated arrangement, and perhaps are more closely connected than naturally adhesive mucus. They are never found in healthy urine, but are present very commonly in catarrhal and calculus cystitis. Tailed or caudate cells are also sometimes present with pelvic epithelium. Often we meet with large cells of scaly epithelium in the urine of females; they are derived from the vagina. They vary much in size and form, and are sometimes very irregular in shape, with uneven, ragged edges.

Renal epithelium is only found in disease. It consists of

round or slightly compressed cells, or masses of material with well-defined central portions or nuclei, which are not cleft like the pus nucleus under the action of acetic acid, but become at first more defined and afterwards paler and smaller. In the urine they are less polygonal and more rounded than they are in the renal canals. Their presence indicates more or less desquamation from the tubes, while their morbid condition and admixture with other products may indicate still greater disease. Thus it is sometimes fatty, the whole space between the nucleus and the cell-wall being filled with fatty globules. The character of this epithelium enables us to diagnosticate the different forms of Bright's disease.

PUS.

Urine containing pus deposits an opaque, creamy sediment, or glairy mass, and is generally alkaline or albuminous. If the sediment is agitated with an equal quantity of liquor potassæ, a dense gelatinous mass results. The microscope, however, is the readiest and most infallible means of diagnosing the pus-corpuscles. The discrimination between the deposit of pus and mucus is not difficult; the deposit of pus is more dense than that of mucus; the pus is known by its nucleus becoming cleft into two, three or five divisions, under the action of acetic acid, whereas, if it is mucus, filaments of mucus will be developed.

There are cases in which we can not prove the presence of pus, though we have every reason to suspect it; this is observed when the urine is strongly alkaline; the presence of carb. of ammonia converts the pus-corpuscles into a slimy, gelatinous-looking mass, which is often mistaken for mucus.

The occurrence of pus in the urine is proof of the existence of suppuration somewhere in the genito-urinary organs. In gonorrhœa, cystitis, and pyelitis we have the existence of other symptoms; the amount of pus is greater in cystitis than in pyelitis or nephritis, and whenever a very large amount is present, the opening of an abscess into some part of the urinary passages may be suspected. Vogel has pointed out a very excellent mode of differentiating, by the character of the pus

corpuscles, superficial from deep-seated suppuration. He says, when the corpuscles are round and well developed, with their characteristic nuclei readily brought out by acetic acid, their origin in a catarrhal inflammation of the mucous membrane, especially of the bladder, may be strongly suspected. On the other hand, pus corpuscles of irregular contour, exhibiting irregular nuclei when treated with acetic acid, or an ill-defined granular mass, consisting of irregularly shaped pus corpuscles and partially destroyed cells, indicate the probable existence of deep-seated suppuration, ulceration, or tubercular disease.

CANCER AND TUBERCLE MASSES.

Cancer Masses are generally found in the urine in the form of an aggregation of cells, mother and daughter cells (parent and secondary cells), cells with thick walls, and tailed and spindle-shaped elongated cells. Their presence indicate the existence of cancer somewhere in the genito-urinary organs. The kidneys are rarely the seat of cancer, the uterus and bladder are more frequently affected. The latter organ is generally the seat of the variety of cancer known as encephaloid or fungus haematoxodes. When the bladder, uterus or urethra are affected, the diagnosis is not difficult, since other symptoms, or a digital and vaginal examination will enable us to render a positive diagnosis. Cancer of the kidney is always more difficult to diagnose. The presence of cancer-cells, which can not be traced to the uterus, urethra or bladder, the existence of haematuria or albuminuria, the pain in the lumbar regions, and the enlargement of the kidney, as ascertained by percussion, will justify us in presuming that organ to be the seat of the mischief. In cases of melanotic cancer, whether it has its seat in the urinary organs or elsewhere, Eiselt, Priban and others have noticed that the urine, on standing, assumes the color of porter, and that on the addition of concentrated nitric acid it instantly presents the same color.

Tubercle.—The little yellow, cheesy masses of degenerated tubercle form a sediment, which is insoluble in acetic acid, and without the aid of the microscope readily mistaken for pus.

The deposit under the microscope, according to Vogel, is seen to consist of pus corpuscles, not exhibiting when treated with acetic acid, normal nuclei; of small irregular nucleoli, with an ill-defined detritus-fragments of cells, disorganized connective tissue and elastic filaments, and an indistinct and finely granular mass, with which occasionally fragments of crystals of cholestrine are mixed. The tubercle may have its seat in the mucous membrane or sub-mucous tissue of the bladder, ureter or pelvis of the kidney.

CYLINDERS AND RENAL CASTS.

Cylinders occur in the urine and have various modes of origin:

1. *From the bladder* as long, flat membrani-form, twisted or folded bodies.

2. *From the prostate* as coägula, two or three times as broad as renal cylinders. They are soluble in acetic acid; amylaceous corpuscles may exist in them.

3. *From the ureter and pelvis of the kidney* the coägula are cylindrical, pyriform or globular.

4. *From the kidney tubes*, cylinders or renal casts are found in various diseases. They vary in breadth from one five-hundredth to one-thousandth of an inch, *i. e.*, from about the breadth of the straight renal tubes to a half or a third of that size. Their length varies from one two-hundredth to one-fiftieth of an inch. The terms used by Dr. George Johnson express the special character of the several varieties of casts.

(a) *Epithelial Casts* are composed of a tube-like aggregation of epithelial cells, derived from the tubes of Bellini, and indicate "desquamative nephritis" or acute Bright's disease. The process of desquamation may cease in a few days without producing any serious consequences; their presence in the urine need not alarm the physician nor his patient; a careful treatment will often make them disappear in a very short time. If pus corpuscles are mixed with sediments of epithelial casts, a

more extensive inflammation, either of the parenchyma, the calices or pelvis of the kidney may be suspected.

(b) *Large Waxy Casts and Small Waxy Casts* (or the hyaline casts of Vogel and Basham). The transparent casts with compound cells, or with isolated transparent molecules and grape-like clusters of granules, represent a stage of chronic subacute disease, and if these casts become more and more loaded with large and gradually increasing fat granules and oil drops, the progress of fatal fatty degeneration is clearly marked—(Basham.)

Da Costa states, "the hyaline or waxy casts may be found in any form of Bright's disease, acute as well as chronic. In the waxy kidney, however, they vastly preponderate, and are of large size. Vogel believes the hyaline casts to be formed, by a fibrinous exudation, either on the small convoluted tubes or on the larger tubes of Bellini, and gives that inflammation the very appropriate name of croupous inflammation." He also states that their presence indicates an extensive inflammation, which is apt to assume a chronic form.

Probin affirms, on the other hand, that the hyaline casts or waxy casts do not consist of fibrin, nor are they uniformly granular like fibrin, which has been for some time coagulated. Moreover, according to this observer, the granular, the hyaline, and the epithelial casts are found in certain of the straight tubes and convoluted tubos, in the contents of the pelvis of the kidneys, and sometimes in the urine contained in the bladder in bodies dead with different affections, when there is no ground to suspect the existence of renal disease. He states also that they are found in the kidneys of animals killed for food. [Flint's Practice, p. 753.] A solution of iodine is the best reagent for making the waxy hyaline or transparent casts. I have pointed out that the passage of crystalline oxalate of lime may give rise to tube casts, and believe that the experience of many physicians will testify to the fact, that the presence of these hyaline casts is not always indicative of grave and incurable lesions of the kidney. The truth of the matter is, that the

urine (in Bright's disease) is too often used in its broadest sense, and that students and physicians do not always make the necessary distinctions in the different affections of the parenchyma of the kidney; they are too apt to regard all forms of Bright's disease as necessarily fatal.

(c) *Granular Casts* or casts covered with disintegrated epithelium, with its compound inflammation corpuscle accompanied by amorphous granular flakes stained with haematin, are chiefly found in the disease which leads to the contracted kidney. They are never seen in the acute complaint, excepting at its close, when it is assuming a chronic form.—(Da Costa.)

(d) *Fatty Casts* and epithelial cells filled with fat are seen in the urine coming from a highly fatty kidney, preëminently Bright's disease.—(Da Costa.)

(e) *Blood Casts* represent more or less hyperæmia and haemorrhage from the kidney, or a calcareous, fatty or lardaceous degeneration of the blood vessels, especially those of the Malpighian corpuscles.

(f) *Purulent Casts* indicate suppuration.

Kidney structures in the urine indicate a breaking up of the structure of that organ.

Corpora amylacea may occur from the prostate gland. *Spermatozoa-Sarcinæ ventriculi vibriones* and *monads* (when the urine contains much mucus), *fungi* in acid urine—e. g., the *penicillium glaucum*, its *spores*, *thallus*, and *fructification*, the *torulæ cerevisiae* in saccharine urine, the *larvæ of distanum hæma tabium*, and various *entozoa* have been observed in the urine, under certain circumstances and in different localities.

I have spoken of the different subjects under different headings, and need not again allude to their significance.

SYSTEMATIC ANALYSIS OF URINE.

The following are the details of the process as recommended by Thudichum :

Test the action of the urine with litmus :

I. It is acid and has no sediment, proceed to 2.

II. It is acid and has a sediment; pour off the clear liquid, filtering, if necessary, and proceed to analyze the filtrate according to 2. Examine the sediment dry.

1. Heat a sample of urine to boiling after the addition of some acetic acid. A coagulum forms, which does not disappear on the addition of nitric acid—*albumen*.

Boil some quantity (500 c.c.) of the urine with acetic acid, filter off the coagulated albumen, and treat the filtrate as under 2.

(a) The coagulum is white—*pure albumen*.

(b) The coagulum is greenish—*albumen* probably colored with *bile*.

(c) The coagulum is brownish-red, probably from *blood*; wash and dry the coagulum; boil with alcohol containing a little sulphuric acid; if the filtrate is reddish, examine with spectroscope for acid haematin or evaporate to dryness; ignite, moisten the ash with a drop or two of concentrated hydrochloric acid, dilute with a little water, filter the solution through a small filter, and add to the filtrate a little potassium sulphocyanide; a red color confirms the presence of blood.

2. Take 400 to 500 c.c. of the clear urine filtered from coagulum or sediment; evaporate in a porcelain dish or a water-bath to a thick syrup; divide the syrup into two parts, one equal to one-third, the other two-thirds of the whole.

(a) Extract the third with strong alcohol, filter, and examine the filtrate.

1. Evaporate a small portion nearly to dryness, and add a little nitric or oxalic acid, and observe the crystalline forms of *urea*, *nitrate* or *oxalate*.

2. Precipitate the larger portion with a few drops of milk of lime and calcium chloride solution and filter; concentrate the filtrate in the water-bath to 10-12 c.c. Transfer to a beaker, add one-half c.c. of strong alcoholic solution of zinc chloride, stir well and allow to stand; *kreatinine chloride of zinc* crystallizes out in warty grains.

(b) Acidify the two-thirds with hydrochloric acid and ex-

tract with ether. Evaporate the ethereal solution and examine the residue for *hippuric acid*.

1. The filtrate will contain *earthy phosphate* and other salts; add ammonia, the *earthy phosphates* will be precipitated.

2. The insoluble residue consists of *mucus* and *uric acid*. Wash off the filter into a test tube, add one or two drops of caustic soda, warm and filter. The insoluble residue is *mucus*. The filtrate contains uric acid and hydrochloric acid; the *uric acid* separates out in crystals; collect and examine under the microscope, also verify the murexide test by applying the presence of *uric acid*.

3. The urine is brown or green; froths on shaking; colors a small piece of immersed filter paper yellow or green; probable presence of *bile matter*.

Place some of the urine upon a white plate and drop in a little strong nitric acid containing some nitrous, without shaking. The fluid turns successively green, blue, violet, and brown; presence of a derivate of coloring matter of the bile.

To a second portion add some lead acetate in solution; collect the precipitate, wash, dry and boil the dried precipitate with alcohol, to which a little sulphuric acid has been added, filter. The filtrate is green from "*biliprasine*."

Evaporate a third portion of 3 to 500 c.c. on the water bath, extract with alcohol; search for biliary acids, *tauro* and *glykocholic*.

4. Take 1 c.c. of urine, dilute it with 4 to 5 c.c. of water, add one-half a c.c. of caustic soda, and add one drop of a very dilute solution of copper sulphate; boil; a red granular precipitate of suboxyde of copper indicates the presence of "*sugar*."

5. Immerse in the urine a piece of filter-paper moistened with acetate of lead solution, if the lead paper turns brown or black *sulphuretted hydrogen* is present.

6. Evaporate 40 to 50 c.c. of the urine to dryness, ignite the residue at a moderate heat until all the charcoal has been burnt off. Boil the residue with water and filter.

(a 1) Acidify a portion of the *filtrate* with hydrochloric acid,

add barium chloride, a white precipitate proves the presence of *sulphuric acid*.

2. Acidify a second portion with nitric acid, add a drop of silver nitric; a white curdy precipitate indicates *hydrochloric acid*.

3. Acidify a third portion with acetic acid, add a little ferric chloride solution, a yellowish-white, gelatinous precipitate indicates *phosphoric acid*.

4. Evaporate the rest to dryness; take up a small portion on the end of a platinum wire and expose in a Bunsen or spirit lamp flame; a vivid yellow color proves the presence of *sodium*.

5. Dissolve a portion in a little water, add a drop or two of solution of platinic chloride; a yellow crystalline precipitate indicates *potassium*.

(b) Boil the residue insoluble in water with a little dilute hydrochloric acid, filter.

1. Boil a portion with nitric acid, add some potassium sulphocyanide solution; a deep red color proves the presence of *iron*.

2. Mix the rest with an excess of sodium acetate, add an excess of ammonium oxalate; a white precipitate proves the presence of *calcium*.

3. Filter off the lime precipitate, add to the filtrate ammonia; a white crystalline precipitate indicates the presence of *phosphate magnesia*.

7. Add to 50 or 100 c.c. of the fresh urine contained in a flask, a little milk of lime, mix and cork loosely, suspending a moistened red litmus paper between the cork and the side of the flask. If the paper turns blue the presence of *ammonia* is proved.

8. Distill some urine with sulphuric acid, add to the distillate a little red fuming nitric acid, and then shake up with a drop of carbon desulphide, which, if *iodine* be present, will be colored pink.

Examination of the Sediment.—Allow any sediment to deposit at the bottom of a conical glass. Pour off as much of the liquid as possible, then take up a little sediment with a pipette, place on a glass slide and examine with the microscope.

A. The urine is acid.

I. The whole of the sediment seems amorphous.

1. On gently warming the whole dissolves—*urates*; confirm by adding a drop of hydrochloric acid; leave half an hour, when, if *uric acid* be present, it will have crystallized out in rhombic tables.

Also confirm by the murexide test.

2. The sediment does not dissolve on warming, but dissolves in a drop of acetic acid without effervescence; presence of *calcium phosphate*.

3. Glistening drops appear in the sediment and disappear on the addition of ether—*fat globules*.

(II) The sediment contains well formed crystals.

1. Small, glistening, transparent octahedra, insoluble in acetic acid—*calcium oxalate*.

2. Four-sided tables or six-sided rhombic plates often appearing grouped in bunches of spindle-shaped crystals—*uric acid* confirm by the murexide test.

3. Regular six-sided tables soluble in hydrochloric acid and ammonia, which char on heating. Boil with caustic soda containing a drop of very dilute acetate of lead; a black precipitate of sulphide of lead confirms the presence of *cystine*.

4. Wedge-shaped prismatic crystals, some separate, some united in form of a cross—*calcium phosphate*.

5. Greenish-brown grains with a radiating crystalline structure—*tyrosine*.

6. Needles or rhombic prisms easily soluble on warming—*hippuric acid*.

III. The sediment contains organized bodies.

1. Twisted fringy bundles, forming points, grains, etc.—*mucus*.

2. Concentrated granular bodies often united into a scale pavement-like mass—*mucus corpuscles*.

3. Circular bi-concave disks mostly yellowish, which swell up and more or less completely dissolve in acetic acid—*blood corpuscles* confirmed by spectroscopic reactions.

4. Round, pale, faintly granular vesicles, of different sizes, which swell up considerably in acetic acid, lose their outward granular surface, and allow an inner nucleus of different form to be seen—*pus*.

5. Cylindrical masses with small vesicles, often mixed with blood and pus corpuscles: so-called *casts of the tubules*.

(a) Casts whose roundish nuclei are clearly visible through a delicate surrounding mass—*epithelial casts of Rellini's tubes*, mostly accompanied by the nucleated, epithelial cells of ureters and kidneys.

(b) Solid cylinders of thick, granular, nucleated nature are *granular renal casts*, and often contain blood and pus corpuscles with fat globules, crystals of calcium oxalate.

(c) Pale, transparent, solid cylinders, only seen with great difficulty—*hyaloid casts*.

6. *Epithelial cells.*

(a) *Pavement epithelium.*

(b) *Epithelial tubes.*

7. *Fermentation and thread fibres.*

8. Short, fine rods, threads, or square lumps, moving about in an undulating manner—*vibriones, spermatozoa sarcina ventriculi*.

B. The urine is alkaline.

I. Crystalline sediment.

1. Rhombic vertical prisms soluble in acetic acid; on mixing with a little milk of lime, ammonia is evolved—*ammonio-magnesian phosphate*.

2. Wedge-shaped opaque masses giving the murexide reaction—*ammonia urate*.

II. Sediment is amorphous, usually *calcium phosphate*.

III. Sediment contains organized bodies; see above under A III.

The following details for the analysis of prostatic and urinary calculi are obtained from Thudichum's Physiological Chemistry:

Calculi, Prostatic.—Minute concretions, from the size of mustard or hemp seeds to that of barley corns. Dissolve powder in acetic acid, and observe evolution of carbonic acid gas. Add to the solution excess of ammonia, and observe that solution remains clear; absence of phosphates of earths; if solution forms deposit, phosphates of earths are present. If necessary, filter, and add oxalate of ammonium—a copious precipitate of calcium oxalate will ensue. The calculi, therefore, consist principally or entirely of *carbonate of calcium*.

Calculi, Urinary—Systematic Analysis.—Powder the calculus; heat a small portion of the powder to redness on some platinum foil, and observe whether any residue is left, which will not burn off.

A. In case it leaves a fixed residue, take a small portion of the original calculus, dissolve in concentrated nitric acid, evaporate to dryness on a water-bath in a white porcelain evaporating dish; dip a glass rod into the strongest ammonia and bring it near the residue in the dish, and observe whether a pink color is produced or not.

I. A pink color is produced, proving that the calculus contains *uric acid*. Observe whether a portion of the calculus melts on being heated.

(a) It melts.

1. And communicates a strong, yellow color to the flame of a spirit-lamp or Bunsen burner—*sodium urate*.

2. And communicates a violet color to the flame, giving the potassium spectrum—*potassium urate*.

(b) It does not melt; dissolve the residue left after ignition in a little dilute hydrochloric acid, add ammonia till alkaline, and then ammonium carbonate solution.

1. A white precipitate falls—*calcium urate*.

2. No precipitate; add some hydric sodic phosphate solution; a white crystalline precipitate falls—*magnesium urate*.

II. No pink color is produced. Observe whether a portion of the calculus melts on being heated strongly.

(a) It melts (fusible calculus). Treat the residue with acetic acid; it dissolves; add to the solution ammonia in excess; a white crystalline precipitate falls—*ammonio-magnesium phosphate*. In case the melted residue is insoluble in acetic acid, treat with hydrochloric acid; it dissolves; add to the solution ammonia; a white precipitate indicates *calcium phosphate*.

(b) It does not melt; moisten the residue with water, and test its reaction with litmus paper. It is not alkaline; treat with hydrochloric acid, it dissolves without effervescence; add to the solution ammonia in excess; white precipitate—*calcium phosphate*. Treat the calculus with acetic acid; it does not dissolve. Treat the residue, after heating, with acetic acid; it dissolves with effervescence—*calcium oxalate*. Treat the original calculus with acetic acid; it dissolves with effervescence—*calcium carbonate*.

B. The calculus, on being heated, does not leave a fixed residue. Treat a portion of the calculus with nitric acid, evaporate and expose to ammonia vapor as before.

I. A pink color is developed.

(a) Mix a portion of the powdered calculus with a little lime, and moisten with a little water; ammonia is evolved, and a red litmus paper suspended over the mass is turned blue—*ammonium urate*.

(b) No ammonia—*uric acid*.

II. No pink color is developed.

(a) But the nitric acid solution turns yellow as it is evaporated, and leaves a residue insoluble in potassium carbonate—*xanthine*.

(b) The nitric acid solution turns dark-brown, and leaves a residue soluble in ammonia—*cystine*.

French Decimal Weights and Measures.

The *metre*, or unit of length at 32° C. = 39.371 English inches at 62° F.
 The *litre*, or unit of capacity = 1000 c.c. = 61.028 English cubic inches.
 The *gramme*, or unit of weight = 15.434 Troy grains.

Table of Apothecaries' Weight and Measure U. S.

Pound.	Troy ounces.	Drachms.	Scruples.	Troy grains.	
1	= 12	= 96	= 288	= 5760	
	1	= 8	= 24	= 480	
		1	= 3	= 60	
			1	= 20	
Gallon.	Pints.	Fluid ounces.	Fluid drachms.	Minims.	Cubic inches.
1	= 8	= 128	= 1024	= 61440	= 231
	1	= 16	= 128	= 7680	= 28.875
		1	= 8	= 480	= 1.804F
			1	= 60	.2256

Relative Value of Troy and Avoirdupois Weight.

Pound.	Pounds.	Pound.	Ounces.	Grains.
1 Troy	= 0.822857 Avoirdupois	= 0	13	72.5
1 Avoirdup's	= 1.215277 Troy	= 1	2	280.

In regard to test-chests, the student and practitioner will see for themselves what they need, and procure the chemicals and utensils as they require them. A suitable apparatus can be obtained from E. B. Benjamin, No. 10 Barclay street, New York; or Bullock & Crenshaw, No. 528 Arch street, Philadelphia. The test-chest furnished to the Medical Officers of the U. S. Army contains all that is required.

EXPLANATION TO THE ILLUSTRATIONS.

The plates have been copied from Neubauer and Vogel's work on Urinary Analysis. Plates I. and II. and Plate III., figures 1 to 4, were originally published in Dr. Otto Funke's Physiological Atlas, to whom we gladly acknowledge our indebtedness.

PLATE I.

Fig. 1.—Hippuric acid obtained from normal urine of man, re-crystallized from a watery solution.

During a very slow formation of the crystals they not unfrequently assume the form of the triple phosphates, and are readily mistaken for them; see left lower third of the field.

Fig. 2.—Uric acid in various forms, obtained either by the re-crystallization of a solution of uric acid, by treating urine with acids, thus decomposing the urates and liberating uric acid, or by spontaneous decomposition.

The various forms of uric acid from the most common form, the rhomboidal plates with obtuse and rounded angles to the more rare modifications are readily discerned. The dumb-bell-shaped forms seen in the upper left part of the figure, and which at times are observed in spontaneous deposits, were artificially produced; they were formerly supposed to consist of lime. Dr. Funke always obtained them by dissolving chemical pure uric acid in concentrated caustic potassa, and decomposing the solution under the microscope by muriatic acid.

Fig. 3.—Urinary sediment composed of uric acid, urate of soda, and oxalate of lime, from the urine of a convalescent from typhus fever. The uric acid crystals are here chiefly seen in large, dense bundles, joined two and two by their bases, each bundle being composed of innumerable long, slender, and whetstone-shaped crystals, which, as a rule, are colorless.

The beautiful shining and envelope-shaped crystals are oxalate of lime. The minute rounded or irregular dark-colored granules, occurring either singly or irregularly grouped together, are the urate of soda, which always appear in the urine in this molecular form.

Fig. 4.—Urinary deposit, composed of epithelial casts and numerous epithelial cells from the bladder of a typhoid fever patient, obtained after death by the introduction of a catheter.

These casts are the epithelial lining of the tubes of Bellini, the rounded nucleated cells are readily discerned through the granular molecular mass.

The isolated wedge-shaped caudate, and spindle-shaped nucleated cells are derived from the ureters, pelvis, and calices of the kidneys.

Fig. 5.—Urinary deposits, exhibiting hyaline casts, epithelium from the bladder, and mucus corpuscles, obtained from the urine of a patient affected with acute miliary tuberculosis.

These casts are, by reason of their transparency and homogeneous composition, difficult of recognition; at times they are, by their contents, rendered more distinct, such as minute granules of urate of soda; the ends are usually club-shaped.

The rounded, elongated, polygonal, and nucleated cells are pavement epithelium from the bladder, and strongly granulated mucus corpuscles.

Fig. 6.—Urinary deposit representing fibrin-casts, blood, and pus corpuscles, together with epithelial cells, obtained from albuminous urine of a typhoid patient, whose kidneys, upon section, exhibited a considerable inflammatory infiltration in the cortical substance.

The granular cylindrical bodies, apparently composed of a molecular substance, are nothing more nor less than coagulated fibrin (croupous exudation), and are exact casts of the tubes of Bellini; some contain a number of pus and blood corpuscles. These corpuscles are seen isolated in considerable number; some blood globules swollen and distended, others still exhibiting a marked central depression. The bi-polar cells have already been described under Fig. 3.

PLATE II.

Fig. 1.—Urinary sediment composed of urate of soda, from the morning urine of a tuberculous patient.

The whitish, yellowish, or brick-dust-colored sediments, so commonly observed in concentrated acid urine, particularly during febrile affections, and which are generally deposited after the temperature of the fluid is lowered beyond that of the body, consist almost always of urate of soda in the granular or molecular form; during rapid deposition the little granules become extremely fine, and are usually congregated in moss-like

groups. At times, after the urine has been standing a few days, some fermentation fungi may be observed.

Fig. 2.—Urinary deposit, composed of urate of soda, phosphates, and coagulated mucus, derived from urine after three days' standing.

The urate of soda here appears in large, dark granules congregated together. The regular granular and membrane-like formation, represented about the middle of the field, are fractions of the peculiar scum formed of the amorphous earthy phosphates during the process of decomposition. The peculiar streaks, both narrow and broad, and apparently composed of fine points and granules, arranged in regular lines, are the so-called *mucus casts*, often observed in acid urine and frequently mistaken for casts; fermentation fungi (particularly near the lower edge of the field) and some strongly granular mucus-corpuscles are also observed scattered over the field.

Fig. 3.—Urinary deposit, composed of triple phosphates and numerous mucus corpuscles, derived from the fresh urine of alkaline reaction and turbid appearance of a patient affected with catarrh of the bladder.

The crystals of phosphate of magnesia and ammonia exhibit various forms, but are always readily recognized. The mucus corpuscles are small and granular, and mostly united with their edges to form large groups.

Fig. 4.—Urinary sediment composed of urate of soda, uric acid, and fermentation fungi, derived from urine which has undergone the process of acid fermentation.

Every normal urine and almost every abnormal urine of acid reaction undergoes the process of acid fermentation; during this period the minute nucleated fermentation fungi are formed and rapidly develop; the liberation of uric acid from the acid urate of soda also takes place during this time, and is seen as a deposit of yellowish-tinged crystals; minute octahedra of oxalate of lime are seen at this period of decomposition.

Fig. 5.—Urinary sediment composed of triple phosphates and urate of ammonia; obtained from the urine of a patient

suffering from paraplegia, consequent on disease of the spinal cord; the urine having undergone the process of alkaline fermentation.

The crystals of the triple phosphates are exhibited in their most common form. The urate of ammonia is at first deposited in the molecular form, but gradually crystallizes into dark globular and highly refractive bodies, from which curved, needle-shaped, conical and wart-like excrescences project.

Fig. 6.—Nitrate of urea is obtained from highly concentrated human urine by means of nitric acid.

PLATE III.

Fig. 1.—Urinary sediment, representing crystals of uric acid, from the urine of a young female affected with acute rheumatism during her menstrual period.

The rhomboidal plates, whetstone-shaped and barrel-shaped crystals of uric acid were of a yellowish-brown tinge.

In addition to the gold-dust-like deposit, quite commonly seen, numerous blood-corpuscles also of a yellowish tinge, swollen and bladder-like, and of variable sizes, can be observed.

Fig. 2.—Human blood corpuscles as treated with water. The gradual changes produced by water on the blood-cells are well exhibited in this figure, beginning along the left margin of the field, and progressing towards the right. The first effect of the action of water is to swell them up, they assume a lenticular and subsequently a spheroidal form, the central depression disappears, and is replaced by a prominence. In consequence thereof the cells appear smaller, the centre becomes bright and the rim dark. The imbibition of water causes them to appear pale, and renders it extremely difficult to distinguish them from the surrounding fluid; they are, however, with care still recognized as extremely hyaline delicate bubbles, which soon entirely disappear. Upon the addition of a concentrated solution of any neutral salt, they appear again with shrunken and crenated edges.

Fig. 3.—Pus corpuscles.

The lower half of the field represents normal pus-cells,

round, pale, slightly granulated and of different sizes; some of which exhibit a single round eccentric nucleus, others may be seen with their nucleus cleft into two or more divisions. The figure also shows some of the corpuscles with sharp contours; others again have extremely faint outlines. The upper half of the figure exhibits the action of acetic acid on the pus-cells; they become swollen, the surface smooth and so hyaline that their contours can no longer be distinguished; the nuclei become, however, now more distinct, and are observed either in the single rounded, elongated, biscuit-shaped or horse-shoe-shaped form, or in the triple and quadruple groups.

Fig. 4.—Cystin, as obtained by the addition of caustic ammonia to a urinary calculus.

Figs. 5 and 6 exhibit the most important and frequent forms of organic deposits, observed in the urine in cancer of the bladder.

(The illustrations of cancer are partly obtained from the valuable treatise of Dr. Lambl, "Ueber Harnblasenkrebs. Ein Beitrag zur mikroskopischen Diagnoslik am Krankenbette mit 4 Tafeln. Prager Vierteljahrschr, 1856. Bd. 49, S. 1, ff.;" and partly the result of original researches of Dr. Julius Vogel).

Fig. 5.—A represents a large fragment of papillary formation of a "villous cancer" (Zottenkrebs) of the bladder, magnified 20-50 diameters.

B represents a terminal fragment of a "villous cancer," magnified about 200 diameters. The interior consists of an amorphous, fibrous ground-work and numerous elongated nuclei, covered externally with a layer of epithelial cells.

C represents isolated cells from the layer of epithelium of a "villous cancer"; they are usually caudate or branched, and contain a large nucleus.

D represents a "villous cancer" of somewhat different nature. An amorphous mass, which forms a warty excrescence and includes large nuclei. The epithelial layer is wanting.

Fig. 6, A.—Fragment of "a villous cancer," composed of

fibrous (hollow?) cylinders, partially covered with an epithelial, layer of small, nucleated cells.

B represents an aggregate of cancer-cells, with large cell cavities, thick walls and nuclei, the latter are frequently enclosed in the cell-wall (B c). The cells are mostly united to form groups by means of an amorphous connective substance (B a) or appear isolated, as in (B b and B c).

C, fragment of an amorphous fibrous cancer-frame-work, with spindle-shaped nuclei and elastic fibres, on which rest larger cells (remains of the epithelial layer). They are, as in (a a) well preserved, or partially destroyed, as in (b).

D, isolated cells probably derived from the epithelial layer of a "villous cancer"; (a a) small, rounded nucleated cells, which are clearly colored red, and at first sight liable to be mistaken for blood-globules; they remain, however, unaffected by the application of acetic acid; (b b) large, irregular and partly caudate cells, upon which can be observed reddish nucleated cells.

INDEX.

PAGE.		PAGE.	
Abnormal urine.....	19	Color of urine, changes in.....	22, 26
Accidental ingredients.....	13	normal	9
Acid fermentation.....	15	Color of pigments, estimation of.....	23
Acidity, clinical import of.....	32, 35	tests for.....	23, 29
Albumen, estimation of.....	79	Composition of normal urine.....	3
Heller's test for.....	78	Corpora amyacea.....	93
Méhu's test for.....	78	Creatine.....	5, 47
Albuminuria, causes of.....	76	pathology of.....	47
Alkaline fermentation.....	16, 17	Creatinine.....	6, 47
Alkaline urine.....	11, 36, 37	pathology of.....	47
Allantoine.....	87	Cylinders.....	91
Ammonia, carbonate of.....	5, 19	Cystine.....	86
magnes. phosphate.....	18	Diabetes mellitus, sp. gr. in.....	32, 71
urate.....	6	causes of.....	71
Basham's test for bile pigment.....	68	Distomum haematoxylum.....	82, 93
Bile in urine.....	67, 70	Earthy phosphates.....	8, 36, 55
indications of.....	70	Entozoa.....	82, 93
Bile, pigment tests for.....	68	Epithelium.....	87
Biliary acids, tests for.....	68, 70	clinical import of.....	87, 88
Biliprasine.....	95	Extractive matters.....	75, 76
Bi-phosphate of soda.....	8	Fat in urine.....	83
Blood in urine.....	80, 82	pathology of.....	83
indications of.....	80, 81	tests for.....	83
source of.....	80, 81	Fermentation test.....	72
Bright's disease.....	91, 93	Fibrin in urine.....	79, 80
Calculi, prostatic analysis of.....	99	Froth in urine.....	95
urinary.....	99, 100	Fungus.....	93
Cancer masses.....	90	Hæmatine.....	94
Carbolic acid cause of black urine.....	22	Hæmaturia.....	80
test for albumen.....	78	pathology of.....	80, 82
Casts, renal and vesical.....	91	Harley's test for biliary acids.....	68
blood.....	93	Heller's test for albumen.....	78
epithelial.....	91	uroxanthine.....	25
fatty.....	93	Hippuric acid.....	85
granular.....	93	Hoppe's test for biliary acids.....	68
hyaline.....	92	Hypoxanthine.....	87
waxy.....	92	Indican.....	25
purulent.....	93	Indigo red.....	26
Chlorides.....	8, 58	blue.....	26
clinical import of.....	59	Inosite.....	75
estimation of.....	61	test for.....	75
pathology of.....	59	Iodine.....	12, 96
Chyluria.....	83	Kidney as defibrinators.....	46
Coagulable urine.....	79	structure.....	93

PAGE	PAGE		
Kryptophanic acid, detection of....	33	Sugar, Trommer's test.....	71
Kyestein.....	84	Sulphates, amount daily excreted..	63
Lactic acid.....	15	estimation of.....	63
Leucine.....	85	increase of.....	62
Lime phosphate.....	8, 36, 55	pathology of.....	62
Magnesia phosphate.....	8, 36, 55	source of.....	9, 62
Microscope, importance of.....	20	Thudichum, systematic analysis of	
Monads.....	93	urine	93, 99
Moore's test for sugar	72	Triple phosphates, formation of....	18
Mucus.....	8, 87, 88	microscopical app- pearance of 18, 19	
Murexide test.....	48	Trommer's test.....	13, 71
Odor of urine	28	Tubercle masses.....	90
Oxalate of lime.....	15, 16, 63, 67	Turbidity of urine.....	12
Oxaluria, causes of.....	64	Tyrosine.....	85
symptoms of.....	64	Urates	6, 7, 48
treatment of.....	67	chemical character of.....	52
Pettenkoffer's test.....	69	pathology of.....	51
Phosphates	8, 54, 88	tests for.....	48, 49, 52
chemical and microscop- ical character of 55, 56		Urea, amount daily excreted.....	4
estimation of.....	56	estimation of.....	40, 45
pathology of.....	54, 55	increase and deficiency... 38, 39	
Phosphatic diathesis.....	54	tests for.....	40
Physical character of urine	9	Uraëmia, causes of	39
Purpurine.....	26	symptoms of.....	39
Purulent casts.....	93	therapeutical indications	
Pus, clinical import of.....	89, 90	in	46
tests for.....	90	Uric acid	6, 47
Reäction of urine.....	9, 10, 32	amount daily excreted....	48
clinical import		estimation of.....	49
of.....	11, 36, 37	pathology of.....	51
variation in.....	11	tests for.....	48
Renal casts	91, 93	Urinary analysis.....	93, 99
Sarcinæ ventriculi	93	Urinary calculi, analysis of...	99, 100
Sarcosine.....	6	Urochrome	27
Solids, total daily excreted.....	30	Urohæmatine	22, 23
fluctuation of.....	31	Uroërythrin.....	26
estimation of.....	30	Uroglaucline.....	25
Specific gravity	29, 32	Urophæine.....	23
indications of	31	Urometer.....	29
Spermatozoa.....	93	Uroxanthine	25
Sugar in urine.....	70, 75	Urrhodine.....	26
cause of high sp. gr.....	32, 71	Vibriones.....	93
estimation of.....	72	Water.....	3
Fehling's test for.....	73	variation	9, 10
fermentation test.....	72	Xanthine	86
Moore's test.....	72		

ERRATA ET CORRIGENDA.

On page 2, 35th line, for *uurine*, read *urine*.
On page 4, 28th line, for 793, read 798.
On page 4, 29th line, for 437, read 487.
On page 10, 23d line, for 1020, read 1029.
On page 17, 19th line, for *Anbeitung*, read *Anleitung*.
On page 17, 34th line, for *fermentive*, read *fermentative*.
On page 22, 23d line, for *chincaphilia*, read *chimaphilia*.
On page 25, 34th line, for *Vierteligahrschrift*, read *Vierteljahrschrift*.
On page 26, 22d line, for *uropodine*, read *urrhodine*.
On page 32, 34th line, for page 16, read page 11.
On page 35, 1st line, for *soiution*, read *solution*.
On page 48, 36th line, for *inurexide*, read *murexide*.
On page 49, 6th line, for *water*, read *urates*.
On page 54, 5th line, for page 12, read page 8.
On page 54, 11th line, for page 4 and 5, read page 18.
On page 54, 21st line, for page 12 and 13, read page 11 and 12.
On page 68, 30th line, for *Flex Hopper's*, read *Felix Hoppe's*.
On page 78, 32d line, for *Mélne*, read *Méhu*.
On page 80, 8th line, for 2697, read 269.
On page 81, 22d line, for *uterus*, read *ureters*.
On page 93, 1st line, for *urine* (in Bright's disease), read term *Bright's disease*.

On page 95, 10th line, for also verify the *murexide* test by applying the presence of *uric acid*, read also verify the presence of *uric acid* by the *murexide* test.

On page 93, 26th line, for *distanum hæmatabium*, read *distomum hæmatobium*.

بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِيْمِ



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